RELAY AND CONTROL REQUIREMENTS FOR PARALLEL OPERATION OF GENERATION (138 kV & 69 kV)

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RELAY AND CONTROL REQUIREMENTS FOR PARALLEL OPERATION OF GENERATION (138 KV & 69 KV)

PPL ELECTRIC UTILITIES

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FOREWORD

The information contained in this document was prepared by PPL Electric Utilities. This information represents minimum design requirements relative to safe and reliable operation for the PPL Electric Utilities system and personnel. However, this shall not relieve the customer from sole and complete responsibility for all aspects of design, installation, and operation of his facilities. Neither PPL Electric Utilities nor any person acting on behalf of PPL Electric Utilities;

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To ensure that all proposed installations are handled uniformly and to minimize the possibility of misinterpreting PPL EU requirements, this document outlines the protection requirements for parallel operation of generation. These requirements are designed to ensure the safety of the general public and PPL EU personnel, and minimize possible damage to PPL EU equipment and that of other PPL EU customers connected to the same line. The amount of required protection applied to a particular generator will vary with the specific location on PPL EU's system.

This protection package, designated as IPR, or Intertie Protective Relaying, is not intended or specified to provide protection for the customer's generation equipment or facilities. The customer must provide additional protection devices to adequately protect customer equipment; any protection of the customer's generation equipment or other facilities that is provided by the IPR protection is coincidental—it must not be relied upon, even partially, for comprehensive protection of the customer's equipment. Accordingly, the current transformers, potential transformers, main protective relays, auxiliary relays, and tripping contacts used in the IPR circuits are reserved exclusively for protection of the PPL EU system; totally separate facilities must be provided for the customer's generation and other equipment protection. No additional relaying, metering or monitoring devices may be included in the current transformer (CT) circuit or potential transformer (PT) circuit designated for IPR protection. Similarly, the relay settings are specified to provide the best possible protection for the PPL EU system for faults in the customer's equipment; these settings may not coordinate well with the customer's low side protective devices or provide complete protection of the customer's equipment.

For NEW installations, this document is to be used in addition to the protection requirements specified in the PPL EU document "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", which covers new installation requirements for the Point of Contact protection. This protection package covers the requirements for the interconnection of the customer with the PPL EU system.

SCOPE

This document is intended for generation installations connected to the PPL EU subtransmission (69 kV and 138 kV) system. The intended generator installations will be connected to PPL EU lines, and are subject to being isolated with PPL EU customers if the PPL EU source substation line termination is opened for any reason.

The installation of the generation equipment shall not cause any reduction in the quality of service to other PPL EU customers.

Generation connected to networked facilities above 100kV (on the PPL EU system, this will be 138 kV and above), will be under the RFC (Reliability First Corporation) and NERC (North American Electric Reliability Council) reliability requirements and standards. The control and protection of these facilities must be reviewed based upon the RFC and NERC requirements and this document. The IPP's control and protection must adhere to the most restrictive of these requirements. This refers to facilities defined by RFC as the "Bulk Electric System".

Due to multiple Authorities Having Jurisdiction (AHJ), the process and requirements will vary for IPP facilities having various MVA capacity levels and connected at different voltage levels.

The Pennsylvania Public Utility Commission (PUC) has enacted rules for Net metering installations below 3 MVA that are NOT covered by the PJM or FERC processes. In general, these will be small installations connected at distribution voltage levels 12 kV and below. The current PA PUC rules can be found on the Pennsylvania PUC state web site.

Typically, installations between 3 MVA and 20 MVA will fall under the PJM Interconnection process, specifically in PJM Manual 14A, Section 3 "Small Resource Interconnection Process." These facilities will generally be connected to 69 kV or higher voltage facilities. The practical limit for connection of generation to the PPL EU distribution system (operating at 12.47 kV), is 1.5 MVA for typical feeders. Generation in excess of 1.5 MVA will be considered on a case by case basis, but generally will not exceed 5 MVA. Facilities above the 5 MVA rating will typically require a 69 kV or higher voltage connection and additional protection equipment.

Any customer connecting to the PPL EU system under the PJM Interconnection process must be aware of and meet the requirements specified in the PJM series of manuals, found on the PJM Interconnection website at: PJM Interconnection Library of Manuals.

Installations at 12 kV will be covered by a combination of the PPL EU REMSI (Rules for Electric Meter Service Installation) document, Relay and Control Requirements for Parallel Operation of Distributed Generation (12 kV and Below), PA PUC and PJM rules as noted above. www.pplelectric.com.

SECTION 1 OVERVIEW

INTERCONNECTING GENERATION WITH THE UTILITY SYSTEM

This document is intended to serve as a reference for PPL EU engineers and IPP sponsors when planning protection for the parallel operation of a generation facility on the 69 kV and 138 kV PPL EU system. *NOTE: the term generation will be used throughout this document to designate ANY form of generation. This would include traditional PURPA installations, as well as newer Merchant Power Installations (MPI), Independent Power Producer (IPP), (DG) Distributed Generation, and (DR) Distributed Resources.* Minimum requirements (as specified in these standards: IEEE 1547 and UL 1741) for generation interconnection are identified to provide for safe and effective operation of the PPL EU system. Some installations may be required to install additional protection, after a review of the proposed generation installation. ***No specific protection is provided for the generator by the IPR relays.***

This document is intended to cover ALL generation connected to the PPL EU 69 kV and 138 kV system. However, since there are multiple AHJ; the intent is to treat all generation facilities in a similar manner.

Generation equipment built and certified to IEEE standards (IEEE 929-latest version, IEEE 1547-latest revision, and IEEE 1547.1 latest revision) and UL 1741-latest version will be permitted to be installed with little or no additional protection requirements, at the site of the generation installation. *However, multiple installations on a single line or substation, or the installation of a large unit, may have sufficient impact that additional protection will be required.*

All inverters to be used for connecting generation to the PPL EU system are required to be certified (listed) to UL1741 and IEEE 1547. The term certified is understood to indicate a NRTL (Nationally Recognized Testing Laboratory) has tested the device to the appropriate standard, in this case UL1741 and IEEE 1547. Further, the inverter vendor must provide upon request copies of the certification of the inverter equipment from the NRTL. Self-certification or certification by a third party that is not listed on the OSHA web site will not be accepted.

For all generation installations, but especially the small residential installations, it is the responsibility of the IPP/customer and their engineer/electrician to determine if the operational voltage limits of the inverter will be exceeded at the maximum operational output of the generation during normal operation of the PPL EU system. It should be recognized that at certain times of the year, the PPL EU system voltage will approach the maximum limit as measured at the meter base of 126 or 252 volts. The addition of generation can cause this voltage to increase, or if there is a sufficiently long branch circuit to the generation equipment, the voltage at the inverters may be high enough for the inverters to trip off on over voltage. It is the IPP/customer responsibility to take the possible voltage rise into consideration in the design of their facility.

Multiple PPL EU Sources

Under no circumstances shall two or more PPL EU lines of differing voltages (12 kV and 69 kV for example) be paralleled through generation facilities. Where one or more sources is intended to back-up the primary supply to a generation facility, the electrical circuit to the primary supply must be interrupted before the circuit to the back-up is closed. (Trapped key interlock switches or break-before-make transfer switches are suitable devices for this type of transfer.)

Multiple sources at the same voltage will be handled on a case-by-case basis.

1.1 INITIATING A REQUEST TO INSTALL OR CHANGE OPERATION OF GENERATION EQUIPMENT

All projects to add or modify an existing business customer's connection to the PPL EU system should start with a call to the PPL Electric Utilities Business Accounts Department at telephone number **1-888-220-9991, menu option 4,** to contact a Business Accounts service representative, who will appropriately respond to your inquiry.

Alternatively, you may initiate a contact to Business Accounts via the PPL EU website at: Business Accounts Department or email us at businessaccounts@pplweb.com.

1.2 POINT OF CONTACT (POC) and INTERTIE PROTECTIVE RELAYING (IPR)

This document defines specific practices required for the interconnection of generation to the utility system at 69 kV through 138 kV. The point of interconnection for a customer facility will be defined by the term Point of Contact (POC), Point of Common Coupling (PCC) as defined by IEEE 1547, or Point of Interconnection (POI) as defined by PJM, which defines the physical point where the customer's facilities connect to the PPL EU system. This is also the preferred location where the Intertie protective relay (IPR) protection is applied.

The POC and IPR protective relay functions MUST be in separate protective relays and must be for PPL EU use only. Under no circumstances will IPR or POC relays be used for customer functions or logic. Where practical, separate dedicated CTs and PTs should also be used for these functions, see section 5.2 Current and Voltage transformers below.

PPL EU will consider allowing the POC relay to provide backup protection for the IPR relay and the IPR relay to provide backup protection for the POC relay IF BOTH relays are provided with the suitable protective functions. Contact PPL EU directly to discuss this option.

Refer to the following PPL document: **Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV),** for specific POC protection requirements.

Customers requiring service at 230 kV or 500 kV voltages must consult PPL EU for the proper **POC** protection. Services at these high voltages will require customized designs matched to the existing protection schemes already on the lines.

Connections at 138 kV and above are expected to have a minimum of two (2) breakers installed between the generation source and the PPL EU system (i.e., A **POC** breaker and a separate generator protection breaker). The POC FID at 138 kV and above must be a breaker; a fuse is not acceptable.

1.3 IPR SYSTEM DESIGN REQUIREMENTS

SCOPE

The scope of this document is limited to the Intertie Protective Relaying (IPR) and Controls only and does not cover the POC protection or any other relaying applied for the protection of the generator or any other equipment associated with the generation facility.

The IPR cabinet or panel will contain all relays and controls specified by PPL EU for a particular installation, with the possible exception of the Out-of-Step and Synch-Check protection schemes, which may be applied on a per generator basis for multiple generator installations.

PPL EU requires a dedicated cabinet with a latching door, suitable for a PPL EU lock. **The IPR protection equipment is installed to protect the PPL EU system from adverse effects of the generation**; for this reason, *control* of this equipment and the associated settings are to remain with PPL EU. This control will be in the form of the locked cabinet (PPL EU lock); in addition, suitable passwords on the protective relays may also be applied. PPL EU personnel must be allowed access to this IPR equipment at all times.

If there is substantial distance or other equipment between the generation equipment and PPL EU, it may be necessary to have the sensing CTs and PTs located at the point of common coupling (PCC). Also in this case, the generation operator may desire to have the IPR relaying operate a breaker other than the generation breaker. When the CTs, PTs, or controlled breaker are remote from the IEEE 1547 compliant equipment, then the protection and drawings requirements below need to be met.

GENERAL

The PRIMARY FUNCTION of the Intertie Protective Relaying (IPR) is to ISOLATE the GENERATOR from the PPL EU system for faults on the PPL EU system or whenever continued operation would be detrimental to PPL EU or PPL EU customers.

The SECONDARY FUNCTION of the IPR is to BLOCK CLOSING of all circuit breakers that can be used to parallel the generation whenever the PPL EU source is unavailable or abnormal.

All relays will use phase-to-neutral potential (67 volt taps) and phase-current (from WYE connected CTs). Proper phasing and polarities must be followed as indicated in

manufacturers' instruction books. **ALL IPR relays and SCADA transducers are to be connected according to PPL EU phase designations.**

All relays must incorporate isolation devices (i.e., test switches), to isolate ALL inputs and ALL outputs of the IPR relaying for testing.

Contact PPL Electric Utilities for a list of currently approved IPR relays and isolation switches at: **Approved Customer Point of Contact and Generator Intertie Protective Devices**.

DRAWING ACCEPTANCE

All IPR drawings are subject to review by PPL EU. The elementary drawings (potential, current, and control), the bill of material for the IPR protection package and the physical layout drawing must be reviewed and ACCEPTED by PPL EU. The IPP is expected and required to submit ALL drawings required to completely review the Intertie Protection Relaying design from the PT and CT inputs, the DC supplies, to the trip and close coils of the controlled equipment as well as any and all interlock devices. This includes any manufacturers or subcontractor drawings. NOTE: all drawings submitted electronically, must be scalable to the original size for plotting. See "Drawing Requirements for Generation Intertie Protective Relay Cabinets" for further information.

ALL drawings submitted to PPL EU for the generation facility, above 10 kVA must be signed by a licensed Professional Engineer in good standing in the Commonwealth of Pennsylvania.

All drawings are reviewed subject to this NOTICE:

> *This information was prepared from a review of customer drawings by PPL Electric Utilities. Drawing review applies only to the general arrangement of the facilities and the primary and the control equipment associated with the Intertie Protection Equipment. Neither PPL EU nor any person acting on behalf of PPL EU (a) assumes any responsibility for the correctness of design, drawings, installation or operation: or (b) assumes any liabilities with respect to the use of, or for damages of any kind resulting from the use of, any comments disclosed in the review document.*

Panel construction shall not begin until PPL EU approval has been obtained on the above drawings.

IPR CURRENT AND VOLTAGE TRANSFORMERS

PPL EU will review the voltage transformer (VT or PT) and current transformer (CT) ratios for all devices required for the IPR relaying package. PPL EU requires WYE-connected VTs (or PTs) and WYE-connected CTs. These VTs and CTs must be relaying class accuracy and be able to support the connected burden during both normal load and fault conditions. Typically, 200 VA PTs (or VTs) and class C400, multi-ratio CTs will be acceptable for facilities using discrete relays. IEEE 1547 compliant equipment using remote mounted CTs and PTs will be required to supply equipment compatible with the

IEEE 1547 manufacturer's specifications. Equipment with lower ratings must be reviewed by PPL EU.

For generation facilities which are subject to PJM approval, the customer must also ensure that the CTs and PTs used to provide PJM SCADA and metering information meet the PJM requirements as discussed in "PJM Manual 01: Control Center and Data Exchange Requirements".

Upon request, PPL EU will supply fault current data at or near the point of interconnection (POI) to facilitate the proper sizing of protective equipment.

NOTE: CT and VT secondary connections for IPR relaying may be shared with POC relaying; however these secondary connections are NOT to be shared with any customer or generation relaying, or revenue metering, without prior PPL EU approval. If potential devices with dual or more secondary windings are used, relay and metering functions may share the same potential device as long as separate secondary windings are assigned to each of the following: customer protection functions, POC and IPR protection functions and revenue metering functions.

ATTENTION: Voltage Transformers at 69kV and 138kV, located on the PPL EU side of the POC circuit breaker MUST have adequate primary (high voltage) fusing to protect PPL EU transmission/distribution facilities from equipment failure.

TRIPPING RELAYS

The current microprocessor-based protective relays typically provide multiple trip and block close contacts. It is expected these contacts will be connected to directly trip and directly block closing of the required breaker.

When a normally de-energized auxiliary relay or lockout is used to trip and block closing of the generator or other breaker, the IPP must install suitable equipment to monitor continuity of this relay coil, without affecting operation. This additional equipment must be designed to be located in the IPR cabinet.

CONTROL SWITCHES

The IPP must provide a PPL EU CONTROL SWITCH (designated PCS), located in the IPR cabinet for PPL EU use. This switch will provide the capability to locally disconnect the IPP's generation from the PPL EU system when circumstances require manual disconnection. See the Appendix 1 for additional switch details.

A standard PPL EU control switch (General Electric Company Type SB-1, Model 16SB1B2X2) or equivalent with flag, sliding contacts; etc. must be used for the PCS (PPL EU control switch). See Attachment LA-94000, Sheet 10, for switch details. Alternative suppliers for this equipment will be considered as long as the functional requirements are met.

The PCS (PPL EU control switch) shall be a three-position switch with spring return from close to normal and from trip to normal. (The "close" position shall be to the right of

"Normal" and the "Trip" position shall be to the left of "Normal." This will maintain compatibility with standard PPL EU controls.)

The PCS (PPL EU control switch) shall be able to trip but not close the breaker designated for isolation of the customer's generation; note that this designated generator isolation breaker can be the point-of-contact breaker, the dedicated generator circuit breaker or a breaker between those two breakers. Selection of the designated generator isolation breaker must be discussed and agreed to by both the IPP and PPL EU. The PCS (PPL EU control switch) will provide an interlock to block closing of the designated generator isolation circuit breaker by the IPP's control switch unless the PPL EU control switch is in the normal-after-close position. There must be provision for a PPL EU padlock to be installed on the PCS (PPL EU control switch) to prevent unauthorized access to this switch. The exception to this requirement is for facilities under PJM agreements and subject to PJM rules and regulations.

BREAKER STATUS

PPL EU must be able to determine the actual status of the generator (on line or off line) before any switching is attempted on the safety switch or point of contact air switch. Indicating lamps (driven by circuit breaker auxiliary switches) and a means of sensing actual current flow (CTs and an ammeter) or a physical indication of the breaker position (breaker semaphore) must be available to the PPL EU switchman to verify that the IPP's generation is not in parallel operation.

INDICATING LAMPS

Two indicating lights should be located within 6" of the PCS (PPL EU control switch): A red lamp (labeled CLOSED) to indicate when the designated generator isolation circuit breaker is closed, and a green lamp (labeled OPEN) to indicate when the designated generator isolation circuit breaker is open.

CONTROL SYSTEMS

The IPP has the option to use either an AC or DC control system, as described below. When a battery system is used for the DC supply, a DC monitoring relay must be installed and functional. Capacitor trip devices shall not be used.

- **AC SYSTEM**

  Typically, AC control schemes may be used on very small generation projects. The AC control system supply must use 60 Hz power derived from the PPL EU line. The system must be designed to be fail-safe and the failure of any single component must result in a trip of the generator breaker.

  NOTE: In AC-powered schemes the generator breaker may be a contactor. In such cases, a latching contactor is not acceptable. The AC system should use continuously energized auxiliary relays with contacts arranged to trip the generator circuit breaker whenever the relays drop out, by interrupting the undervoltage trip coil.

If a molded case circuit breaker (or equal) is used, it must be equipped with an undervoltage trip option.

All installations must isolate (trip) the generator in such a manner that return of the generation (i.e. closure of the generator or POC breaker) can only occur by:

- A manual operation under the direct control of the PPL EU System Operator/Transmission System Operator, or
- A time-delayed automatic synchrocheck or voltage-check supervised operation after the PPL EU source has returned to normal.

Under no circumstances is the generator contactor (breaker) to close immediately upon restoration of the PPL EU source. Automatic operation of these facilities must be discussed with PPL EU.

A white lamp and nameplate should be provided to monitor the AC source.

- **DC SYSTEM**

This system will use a battery to supply tripping energy to the generator circuit breaker. This DC source must be continuously monitored by the (27/DC) undervoltage relay which will trip the generator circuit breaker if the DC source voltage falls below 10% of nominal. In general, the DC system should use normally de-energized relays.

All such installations must isolate (trip) the generator in such a manner that uncontrolled automatic reclosing of the generator breaker cannot occur for:

- A manual tripping operation, or
- An automatic (protective-relay initiated) operation. In such situations, a time-delayed automatic synchrocheck or voltage-check supervised operation is required to close the generator breaker (contactor) after the PPL EU source has returned to normal.

Under no circumstances is the generator contactor (breaker) to close immediately upon restoration of the PPL EU source. An automatic reclosing operation of these facilities must be discussed with PPL EU prior to implementation.

An amber or yellow lamp with a nameplate should be provided to monitor the DC source.

PPL EU RECLOSING

The requirement for synch-check or voltage supervised reclosing of the generation isolation breaker provides protection of the PPL EU system and the equipment of PPL EU customers. Unsupervised reclosing with parallel generation could cause damage to

customer's equipment. It is the IPP's responsibility to evaluate the potential effect of PPL EU reclosing practices on the generation system and to provide suitable protection.

PPL EU lines operated at 69 kV and 138 kV utilize 3-shot automatic reclosing with the first reclose delayed approximately 1.5 seconds. Reclosing logic for these lines may need to be modified to include synchronism check relaying and/or direct transfer trip (DTT) signaling facilities to minimize the possibility of closing out-of-phase into an isolated generator.

TARGETS

IPR relays must be equipped with targets that indicate operation of the relay. These targets are to be arranged in the control circuit to operate only when the associated relays trip the designated generator isolation breaker (which could consist of the point-of-contact circuit breaker). Microprocessor-based relays will have internal targets (typically LED indicators) to indicate the type of fault and trip status.

INDICATING METERS

PPL EU requirements for POC protection and control state that an ammeter and ammeter switch (General Electric Company, Westinghouse, or Electro Switch) shall be installed to indicate the flow of three-phase currents in the POC FID.

Since SCADA is required to be installed at all customer installations with generation at both 138 kV and 69 kV, the above ammeters should be replaced with suitable IEDs (Intelligent Electronic Devices). This device will be directly connected to the PPL EU SCADA to supply the required analog data, equipment position and must also supply local indication of current.

CURRENT AND POTENTIAL CIRCUIT GROUNDING

Neutral circuits must not be confused with the station ground. All current and potential neutrals are to be isolated from all other circuits, and grounded at one point only. The preferred grounding location will be at the Intertie protective relay (IPR) cabinet, on the cable side of the isolating links.

VISIBLE BREAK SAFETY SWITCH (or visible breaker disconnect switch)

DEFINITION

The Visible Break Safety Switch, when in the open position, allows the physical contacts to be viewed and provides electrical isolation of the generator from the PPL EU system.

ACCEPTABLE DEVICES

Devices in compliance with IEEE 1547, devices designated for use as 'visible break disconnect', fused disconnect switches, circuit breakers that can be physically removed from switchgear and locked on the removed position.

NON-ACCEPTABLE DEVICES

- Load-break switches with arc chutes that obscure a direct view of the contacts with the switch in the open position.
- Molded case circuit breakers.
- Any device with hidden or non-observable contacts

This device is required on all generation installations ***except the single-phase certified inverter based installation of 10 kVA or less.***

A "racked out" breaker can be considered a visible break for large installations using switchgear, if it is capable of being locked in the "racked out" position.

If the facility requires load-break capability, then a second device must be installed in series with the visible break safety switch, to provide the load breaking capability.

This visible break safety switch is an important safety item and must be reviewed by PPL EU Engineering for correct application, correct position and correct type, prior to the start of construction. A warning sign must be placed to warn that both sides of the visible break safety switch may be energized in both the open and closed positions.

Contact PPL EU for the latest specification, possible switch locations, and types of switches available.

1.4 IPR CABINET

PPL EU requires control of the intertie protective relaying (IPR) package, including SCADA and DTT schemes. This control shall be provided by a dedicated locked cabinet which contains all of the IPR relays, auxiliary relays, SCADA and DTT equipment with a PPL EU lock on the cabinet door (additionally, passwords may be applied on the IPR relays). The IPR relay package is provided strictly for protection of PPL EU's system from issues in the customer's facilities; NO customer's generation or other equipment protection or control logic is to be implemented in the IPR relay package. PPL EU will specify relaying requirements and any special metering for the generation installation.

This IPR cabinet and/or equipment is to be located inside of a suitable building to protect the sensitive electronic equipment from the weather and to provide shelter during maintenance activities. Locating this equipment in a pole-mounted cabinet along a distribution line, for example, is **not acceptable**. Locating this in a metal enclosed switchgear facility would be acceptable, but thermostats and heaters must be provided.

IEEE 1547 compliant equipment will typically be housed or otherwise included in the generation facility. For this reason, the specifications below will not apply to this

equipment. However, if additional protection, control, or monitoring equipment is required, then these requirements should be followed as closely as possible for the proposed installation. Special purpose schemes may be required depending on the impact of the facility.

1.4.1 GENERAL DESIGN

- Only "Intertie Protective Relays and Controls" as detailed by PPL EU may be installed in the IPR cabinet. The IPR relays will NOT contain any IPP or generation logic, interlocks, alarms, or controls.
- The IPP will furnish all equipment required for the IPR cabinet, except for special metering equipment and the SCADA protocol converter, if required.
- All component (relay, resistor, fuse, etc.) ratings and ranges for the IPR package must be reviewed by PPL EU.
- The IPP is requested to identify PPL EU as the end user to all suppliers of protective relays and switches. In general, PPL EU will control the equipment; PPL EU requests vendor notification for possible firmware updates or manufacturers service bulletins.
- The maximum voltages allowed in the cabinet are 140 VDC and 240 VAC nominal. Any voltages above this level must be barricaded and labeled.
- All relays must be current production utility grade relays, and must be reviewed by PPL EU. PPL EU will supply a list of currently approved vendors; see **Approved Customer Point of Contact and Generator Intertie Protective Devices**.
- PPL EU will inspect the cabinet prior to assuming operational control; any deficiencies must be corrected by the IPP before acceptance
- The IPP is responsible for mounting the cabinet in an easily accessible location. The IPP shall provide an access procedure to PPL EU for accessing all equipment under the responsibility of PPL EU.
- The IPP shall supply copies of the drawings listed below for review by PPL EU. Contact PPL EU for the specific quantity required, if paper copies are to be supplied. AutoCAD is the preferred electronic format; however, PDF is also acceptable. The drawings will be assigned a PPL EU drawing number, entered into the PPL EU drawing system and re-issued as the 'drawings of record' for the IPP installation.
- ALL drawings must be suitable to be scaled to "D" size (22 inches by 34 inches), except for reports, word or excel documents. Reduced size drawings are NOT acceptable.
- PPL EU strongly recommends that two (2) IPR relays be provided, so that continued operation of the generation facility will be allowed upon failure of one IPR relay until the failure can be repaired or the relay can be replaced. Failure of a single IPR relay installation requires immediate disconnection of the generation from the PPL EU system.

- PPL EU will maintain control of the IPR equipment and will witness all testing performed by IPP personnel or contractors.

1.4.2 DRAWINGS

For a complete discussion of drawing requirements and expected drawing content, see Section 8, Drawing Requirements.

Potential/current elementary - showing the IPR equipment

Control elementary - showing the circuit breaker controls

Wiring diagram or wire list - for the IPR equipment and cabinet

PPL EU will review elementary drawings typically within **30 working days** of receipt. Wiring diagrams or lists will not be reviewed. Panel construction should not begin until PPL EU has reviewed the elementaries.

The IPP is responsible for the accuracy of all drawings.

The IPP shall supply two copies of all "As Built" drawings, the Description of Operation and instruction books for relay switches, auxiliary relays, VT, CT and any other devices as requested by PPL EU, prior to final acceptance of facility.

1.4.3 EQUIPMENT HOUSING

For outdoor installations, there must be a minimum three (3) feet of clearance between the IPR cabinet and any fence or other structure that might interfere with the opening of the doors or access to the cabinet. The IPR equipment can be installed in a switchgear type line up of cabinets (instead of a separate IPR cabinet—an option which must be discussed and acceptable to PPL EU) provided that sufficient clearances exist for access to the IPR cabinet, per NEC and NESC standards.

For indoor installations all walkways around the IPR cabinet must be a minimum of three (3) feet wide. Any other structures or cabinets must not obstruct full opening of the doors.

Following are the guidelines for the IPR equipment cabinet:

A. General Construction

The cabinet minimum size must allow easy access to all components and if equipped, must not restrict motion of internal swing panel.

1. IPR cabinets shall conform to specifications for a NEMA Type 4 Enclosure. Specifications for these enclosures are contained in NEMA Standard ICS 6 (latest version).

2. Single-door cabinets will need the following:

a) A three-point latch handle on the door with provisions for PPL EU's padlock (3/8" hole).

b) A latch or equivalent to keep the door in the 100 degree and 120 degree open positions and hold it there if so desired. A permanent stop should be provided so that the door will not be opened beyond the 120 degree open position.

c) The cabinet shall have a fixed rear panel suitable for device mounting.

d) An all-around door gasket of neoprene or equivalent for outdoor cabinets.

e) A continuously-hinged equipment panel, opening in the same direction as the door.

f) A handle to facilitate opening and closing of the hinged equipment panel.

g) A latch or equivalent to keep the hinged equipment panel in the open position or the fully closed position, and hold it there.

h) All components and wiring must be accessible from the front door.

3. For double-door cabinets all components and wiring must be accessible from the front (and/or rear) doors. If all components are not accessible from the doors, then the cabinet shall have a continuously-hinged panel opening in the same direction as the front access door.

4. IPR relays may be mounted on the doors of cabinets not exposed to weather. The PPL EU control switch is to be mounted in a convenient location to allow for easy access if switching is required. The intended use of this switch is for PPL EU use. The Customer is not to change the position of this switch without contacting PPL EU first.

5. The IPR controls and lamps may be mounted on the door provided that components subjected to an outdoor environment are of weatherproof construction.

6. Space shall be provided near the terminal blocks to allow connection of conduits.

7. Hinges exposed to the weather shall be stainless steel or equivalent non-rusting material.

8. One duplex 120 VAC, 15 amp, receptacle must be located in the cabinet or within 10 feet of the cabinet and must be accessible for PPL EU use. This circuit cannot be supplied by the PT's or VT's used for relaying.

9. Cabinet is to be labeled "Generation name--IPR cabinet" in black letters with a yellow background and a minimum height of 1".

B. Heaters

1. Heaters are required in all outdoor cabinets to control condensation, and shall be operated at 120 VAC, and rated at 125 VAC.

2. Heaters shall not be located near a device when the performance of that device is dependent on ambient temperature.

3. A protective screen or shield shall enclose all heaters.

4. Thermostats may be installed subject to PPL EU review to control heat during summer months and maintain an adequate temperature differential if there is sufficient heat provided by other components.

C. Grounding

1. Cabinet and duplex receptacle must be solidly grounded.

1.4.4 WIRING - Guidelines

A. General

1. Cabinet wiring shall meet current NEC and industry standards, and suitable for operation at 90°C.

2. Cabinet wiring should be free from abrasions and tool marks, and all bends of wires shall have a minimum of 1/4" radius.

3. All wires should be anchored to the cabinet or bundled when running between devices. Wiring should be installed so that it can be visually traced and checked.

4. Wiring should be installed so as to avoid damage to the cable and its insulation. Movement of the hinged panel shall not damage the cable or its insulation or cause stress to the termination points on the panel or on the door.

5. Wires shall be installed such that heat from devices shall not cause cable or wire damage.

6. Wiring and device location should not prevent the removal of any equipment, block access to equipment for inspection and maintenance.

7. All equipment should be mounted and wired in such a manner that no energized terminals or connections are exposed with cabinet swing panels and doors closed.

8. All protective relays or IEDs (Intelligent Electronic Devices) not equipped with internal isolation devices must be connected through an external test device (i.e., WHSE FT-1 or similar as determined and accepted by PPL EU). ALL

inputs and outputs for protective relays, IEDs and analog sensing devices are to be connected through suitable test switches. Further, the switches are to be connected to allow the isolation of the device and the injection of current or voltage WITHOUT disturbing other devices that may be connected to the same CTs or PTs.

9. All incoming and outgoing cables/conductors will terminate on sliding link terminal blocks located in the IPR cabinet.

B. Terminal Blocks

1. Terminal blocks shall be mounted such that the connections and links are accessible and not blocked by projecting equipment.

2. Terminal blocks shall be mounted a minimum of 6" from sidewalls and adjacent equipment and a minimum of 4" above the bottom of the housing.

3. Terminal blocks shall be mounted such that the sliding link:

   a. Falls closed when loosened, if mounted in horizontal rows.

   b. Moves toward the front of the cabinet when opened, if mounted in vertical rows on side panels.

   c. Moves away from the panel centerline when opened, if mounted on the rear panel.

4. There shall be a minimum of 10% or 2 (whichever is greater) spare terminals included in the cabinet for modifications.

C. Terminal Connections

1. Wires terminating on a threaded stud such as a relay terminal will be terminated with ring tongue lugs, which completely encircle the screw or the stud. The crimping tool should be suitable for the connectors used.

2. Wires terminating in a screw-clamp will not require any type of lug since the terminal block will accept a bare, properly stripped wire. Sufficient torque should be applied to each screw to secure the wire firmly in the yoke.

3. Soldered terminals or connections should generally be avoided.

D. Wiring Identification

A suitable means of identifying the conductors or wiring should be employed to provide a method to trace the wiring.

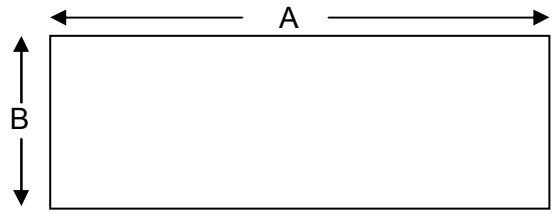
E. Nameplates/Device Identification

Suitable nameplates should be applied to the various pieces of equipment to avoid miscommunication or switching errors. The actual text on the nameplates should be shown on the drawings for PPL EU review.

The same wording on these nameplates should be referenced in any operational instructions.

Below is a typical list of nameplate schedules.

NAMEPLATE SCHEDULE



NOTE: All dimensions are shown in inches.

DIM A	DIM B	HEIGHT OF LETTERS	WHERE USED
2-1/2	1	7/32	All primary circuits on generating or substation switchboards (up to two lines)
2	¾	1/8	Equipment on switchboards or in cabinets (up to 3 lines)
2-1/4	1-1/2	1/8	Equipment on switch boards or in cabinets (up to 3 lines)
4	1	1/8	Equipment on switch boards or in cabinets (up to 4 lines)
3-5/8	¾	1/8	3 gang fuses and indicating lights (up to 3 lines)
2-3/4	1-1/4	1/8	Equipment on switch boards or in cabinets (up to 5 lines)
1-5/8	13/16	1/8	SCADA
4-1/2	1	7/32	Small cabinet doors (up to 2 lines)
8	2	1/2	Large cabinet doors (up to 2 lines)
3-1/2	1-1/4	7/32	Identification on front and back of switchboards (up to 3 lines)

1.5 METERING OF ELECTRIC SERVICE AND GENERATION

IPP installations may require metering facilities not discussed in PPL EU standards such as REMSI (REMSI will cover the metering requirements for IPP facilities connecting to PPL EU's 12 kV system). To obtain these requirements, contact PPL Electric Utilities Business Accounts Department at telephone number **1-888-220-9991, menu option 4,** to contact a Business Accounts service representative, who will appropriately respond to your inquiry.

Alternatively, you may initiate a contact to Business Accounts via the PPL EU website at: Business Accounts Department or email them at businessaccounts@pplweb.com.

The subject of metering needs to be discussed in detail to ensure that the correct sensing equipment is installed for the desired operation. There are many variations on

the sale and purchase of the power associated with these types of facilities. A complete discussion of all of these options is outside the scope of this document; contact PPL Electric Utilities for the various options.

In general, all CTs, PTs and meters for Billing Metering will be provided by PPL EU along with necessary information about metering requirements. No relays or other meters are to be connected to the CTs and PTs used for Billing Metering. Similarly, no customer substation loads will be connected to billing metering CTs or PTs.

Generators that intend to participate in the PJM market will need to make arrangements to get specific information to PJM in a timely manner. One method to accomplish this is the installation of a PJM SCADA RTU. This PJM SCADA RTU uses the Internet to transmit data to PJM and can also connect to revenue meters to get the required information. This option must be discussed if PPL EU supplies the metering equipment.

1.6 DEFINITIONS OF ACRONYMS AND ABBREVIATIONS

The following defined acronyms and abbreviations are used for various utility and customer facilities' configurations:

AC	Alternating Current
AHJ	Authorities Having Jurisdiction
ANSI	American National Standards Institute
BIL	Basic Insulation Level
CTs	Current Transformers
DC	Direct Current
DG	Distributed Generation (aka – generator)
DR	Distributed Resource (aka – generator)
DTT	Direct Transfer Trip
FERC	Federal Energy Regulatory Commission
FID	Fault Interrupting Device (a circuit breaker or fuse)
IEEE	Institute of Electrical and Electronics Engineers
IPP	Independent Power Producers (aka – generation provider)
IPR	Intertie Protective Relay (can refer to a relay or a protection package)
KI	Kirk Key Interlock
NEC	National Electrical Code
NERC	North American Electric Reliability Council
NESC	National Electrical Safety Code
NUG	Non-Utility Generator (aka – generation provider)
PCC	Point of Common Coupling (synonymous with POC and POI)
PJM	Pennsylvania-New Jersey-Maryland Interconnection
PLC	Programmable Logic Controller

POC	Point of Contact (synonymous with PCC and POI)
POI	Point of Interconnection (synonymous with PCC and POC)
PPL EU	PPL Electric Utilities
PUC	Public Utility Commission
PTs	Potential Transformers
REMSI	Rules for Electric Meter and Service Installations
RFC	Reliability First Corporation
RTU	Remote Terminal Unit (for SCADA)
SCADA	Supervisory Control And Data Acquisition
TCM	Trip Circuit Monitor
UL	Underwriter's Laboratories
UPS	Uninterruptible Power Supply

TABLE 1

RELAY DEFINITIONS AND FUNCTIONS FOR FIGURES

(Based on ANSI/IEEE Standard Device Numbers)

TYPE	FUNCTION	DESCRIPTION
21Z1	Zone 1 Distance	Provides a trip signal for a power system fault on the PPL EU supply line.
21Z0S	Out-of-Step	Provides a trip signal for loss of power system-generator synchronism.
25	Synchronism Check	Provides a 'permission to close signal' to the breaker used to parallel the generation to the PPL EU system.
27GEN	Generator Voltage Check	Used to block closing of generator breaker (or other) if voltage is present on generator side. Used primarily with induction generators.
27I	Instantaneous Undervoltage	Provides a trip signal within three cycles of an undervoltage condition; also provides a block closing signal until source is normal.
27N	Narrow Band High Accuracy Undervoltage	Set above 27I or 27T; provides an alarm to generator operator and a trip after a delay (via 62L) of several minutes. (99% reset)
27T	Time Delay Undervoltage	Set at 94% of nominal voltage with a time delay of 0.1 to 2.0 seconds to override local voltage dips.
27DC	Battery Monitor	Set to trip the generator breaker when the battery reaches ≅90% of nominal DC voltage with a time delay sufficient to override momentary voltage transients.
32	Power Directional	Monitors power flow into PPL EU system.
51V	Torque-Controlled Time Overcurrent	Set to approximately 25% of the machine full load rating with the torque control being supplied by the 27 relay(s).
50/51	Time and Instantaneous Overcurrent	This is the POC protection and is connected to monitor phase current flow on the high side of the transformer.
50/51N	Time and Instantaneous Overcurrent Neutral	This relay is connected to monitor the neutral current flow in the high side of WYE connected transformers. It is usually set to 1 amp secondary current.
59I	Instantaneous Overvoltage	Set at 120% of nominal voltage

59N	Narrow Band High Accuracy Overvoltage	Set below 59I/59T; provides an alarm to generator operator and a trip after a delay (via Overvoltage 62L) of several minutes.
59T	Time Delay Overvoltage	Set at 106% of nominal voltage with a time Overvoltage delay of 0.1 to 2.0 seconds
62	Auxiliary Timer (Short Time)	Used with 27I and/or 59I to produce 27T and/or 59T function.
62L	Auxiliary Timer (Long Time)	Used with 27N and 59N to provide several minutes of delay to allow plant operator to correct voltage deviation.
810	Overfrequency	Typically set at 60.5 Hz.
81U	Underfrequency	Typically set at 59.5 Hz with no time delay. May be set to 57.5 Hz with 5.0-second delay for large units to coordinate with load shedding relays.
DTT1	Direct Transfer Trip	Sends a signal from PPL EU Terminal A to trip a customer's generator.
DTT2	Direct Transfer Trip	Same as DTT1 except to Terminal B.

NOTE: For all installations, the preferred relays are microprocessor-based units which usually include multiple protection and/or control functions. These relays provide many of the above functions in one case as well as oscillographic and sequence of events capability. ALL microprocessor-based relays are to be supplied with suitable communication software to allow transfer of data and settings from a personal computer and are required to derive control power from a DC source. AC supply of microprocessor-based relays from the grid is not acceptable.

Protection designs using a single microprocessor-based relay have the potential to lose ALL protection upon failure of the microprocessor-based relay. Therefore, if only one (1) microprocessor-based relay is installed, the relay failure (or health) contact must be connected to isolate the generation from the PPL EU system upon failure of the relay. Installation of a second or backup relay eliminates the need for this mandatory trip, and is strongly recommended.

PPL EU will consider allowing the POC relay to provide backup protection for the IPR relay and the IPR relay to provide backup protection for the POC relay IF BOTH relays are provided with the suitable protective functions. Contact PPL EU directly to discuss this option.

1.7 POWER TRANSFORMER CONNECTIONS AND VECTOR DIAGRAMS

All three phase Generation must be isolated from PPL EU customers by a power transformer. For new three-phase installations the ***REQUIRED*** isolation transformer is WYE-grounded high voltage side (PPL EU supply side). For 138kV and 69kV installations the low voltage side (customer load side) will typically be DELTA, but the generation can specify WYE if necessary. If a WYE-WYE transformer configuration is used, the transformer must be solidly grounded on the low voltage side. The transformer high side winding is to be specified for full insulation to allow for impedance grounding. The need for impedance grounding depends on the impact of the generation to the PPL EU system. It will not be necessary in all cases. Existing facilities which install generation will typically have a DELTA high side and WYE low side transformer. This will be accepted by PPL EU; however, additional high voltage protection may be required. Further, the generator sponsor should review the transformer connection and the impact on the connection of the generation equipment to the existing plant.

PPL EU System - 230 kV and Below

PPL EU employs a "C-B-A" phase sequence at voltage levels of 230 kV and below. Most references site an "A-B-C" or "1-2-3" sequence. For PPL EU, the equivalent would be "C-B-A" or "3-2-1."

PPL EU chose to connect the high side of DELTA-WYE power transformers in the following manner in all divisions except the Lancaster Division.

A phase - H1 Bushing
B phase - H2 Bushing
C phase - H3 Bushing

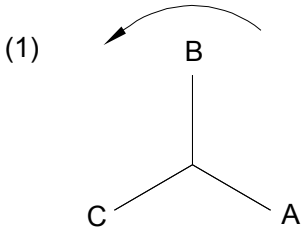
For the Lancaster Division:

C phase - H1 Bushing
B phase - H2 Bushing
A phase - H3 Bushing

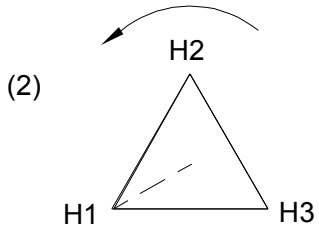
For all PPL EU divisions except Lancaster, the transformer connections noted above and the standard phase relationships and transformer terminal designations for three-phase power transformers as outlined in IEEE Standard C57.12.00-latest version result in a non-standard phase displacement of the low side voltage leading the high side voltage by 30 degrees.

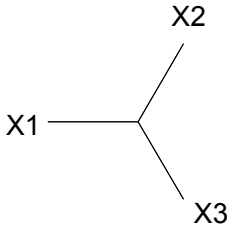
For Lancaster Division, the transformer connections noted above and the standard phase relationships and transformer terminal designations for three-phase power transformers as outlined in IEEE Standard C57.12.00-latest version result in the low side voltage lagging the high side voltage by 30 degrees.

The diagrams on the following page illustrate the transformer connections and angular displacements noted in the discussion above.

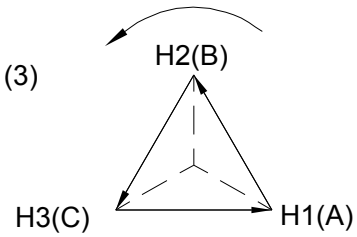


PPL 230KV AND BELOW
C-B-A ROTATION

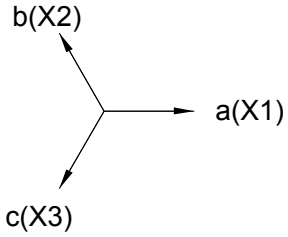




INDUSTRY STANDARD

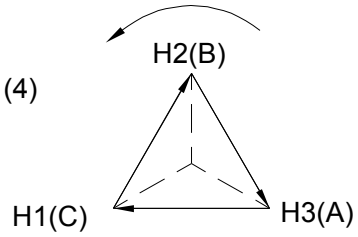


HIGH VOLTAGE

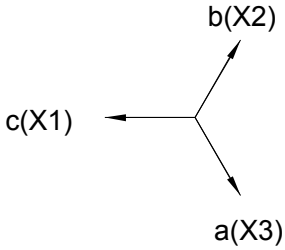


LOW VOLTAGE

LOW VOLTAGE LEADS
HIGH VOLTAGE BY 30°
(SYSTEM).



HIGH VOLTAGE



LOW VOLTAGE

LOW VOLTAGE LAGS
HIGH VOLTAGE BY 30°
(LANCASTER).

1.8 BASIC INSULATION LEVELS AND CLEARANCES

The generator owner's equipment BIL is expected to coordinate with established PPL EU designs. In addition, NESC clearances are to be maintained. Refer to the PPL EU document: Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV) for additional BIL information.

1.9 VOLTAGE LEVELS AND VARIATION

Refer to the PPL EU document: Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV) for additional information on the primary voltage levels used on the PPL EU system.

1.10 INSTALLATIONS INVOLVING 15 KV CLASS SWITCHGEAR

Refer to the PPL EU document: Point of Contact Requirements For Distribution Voltage Customer-Owned Facilities (12 kV Supply) for additional information.

1.11 GENERATOR ISOLATION BREAKER

This breaker is typically the main device used to isolate the generation from the PPL EU system; this breaker could be the POC breaker, the generator breaker or any other appropriate breaker (subject to PPL EU review) between the PPL EU point of interconnection and the generator. It must be able to withstand 2 per unit voltage (minimum) across the open contacts. It should be equipped with breaker failure protection to provide an alternate means of isolation of the customer's generation should the breaker fail to trip. It may be necessary to coordinate the breaker failure relaying with PPL EU protective relaying. SF-6 breakers require special consideration since loss of SF-6 gas pressure will reduce the breaker's dielectric capability and the ability to interrupt current. Consequently, loss of SF-6 gas will initiate both a local alarm and a SCADA alarm, and then trip the breaker before the gas pressure is too low to operate the breaker. The manufacturer's recommendation for the specific breaker will be carefully reviewed to determine if the suggested operation on loss of SF-6 gas will be acceptable on the PPL EU system.

1.12 BREAKER FAILURE PROTECTION

Breaker failure protection must be applied to the breaker chosen as the generation isolation breaker. Failure of the designated breaker must initiate the breaker failure scheme to clear the generation from the PPL EU system.

If the generator breaker is selected to isolate the generator, then operation of the breaker failure scheme must clear the customer's POC breaker, or a breaker located between the generator breaker and the POC breaker. If the POC breaker is the designated breaker to isolate the generator, then operation of the breaker failure scheme must clear the generator breaker or a breaker located between the generator breaker and the POC breaker. If an intermediate breaker is designated to isolate the generator, then operation of the breaker failure scheme must clear the POC breaker or the generator breaker.

The objective of the breaker failure scheme is to isolate the customer's generation from the PPL EU system for either of the two conditions:

- Faults detected in the customer's equipment, or
- Failure to clear the customer's generation from the PPL EU system upon receipt of a DTT signal from the remote PPL EU supply substation.

If the customer's station configuration does not allow the application of a local breaker failure protection scheme (designed to isolate the customer's generation from the PPL EU system when needed), then a DTT signal can be initiated upon breaker failure of the customer's breaker to remotely trip the PPL EU substation breaker supplying the IPP's facilities.

Design and operation of the breaker failure scheme must be discussed between the IPP and PPL EU.

1.13 TELEPHONE CIRCUITS

Telephone circuit requirements for IPP installations vary depending on the size of the generator and how it is connected to the PPL EU power system. The different types of telephone communication circuits are discussed below--any or all may be required for a customer's generation installation.

The IPP is responsible to order the necessary telephone communication circuits; PPL EU does not initiate the ordering process with the local telephone companies. See Appendix 3 for information discussing specific information required to place an order with the local telephone company for the required telephone lines.

All leased telephone circuits (DTT, SCADA) must be available approximately one month prior to synchronism date. (Generally, this requirement applies only to larger systems.)

- SCADA - Requires a dedicated 4-wire circuit. The determination of the type of telephone communication circuit (copper or fiber) to be supplied will rest with the telephone company.

- DTT - Requires a dedicated 4-wire circuit. The determination of the type of telephone communication circuit (copper or fiber) to be supplied will rest with the telephone company.

- Voice grade - A voice grade telephone circuit is required for voice communication. Further, an extension phone should be located in the vicinity of the SCADA and DTT equipment.

- Revenue metering – PPL EU Metering Engineering prefers to have a Verizon or AT&T cellular service available for the revenue metering equipment to communicate with PPL EU.

PPL EU will provide specific information on the type and quantity of phone circuits to be provided; typical protection requirements for the telephone circuits are discussed below. The local telephone company may have additional requirements.

All copper phone circuits required by PPL EU (SCADA, DTT) must be equipped with ***telephone company approved*** high voltage isolating devices. See IEEE 487-2015 latest version, and the local telephone company specific requirements. NOTE: these specialized phone circuits tend to be long lead items (on the order of 3-6 months or even longer), and **may not be available in all locations**. PPL EU may be able to make a determination at the initial study phase to see if the required telephone services are available and suggest alternatives if they are not.

In addition, telephone companies may have their own specific requirements. Some *typical* requirements are:

- IEEE 487 – "The dedicated cable should be routed in a well-drained insulated conduit, e.g., polyvinylchloride (PVC), within the station ground grid area."
- IEEE 789 – "In the case of the dedicated communications cable leaving the station, it is recommended that this cable be installed in a continuous PVC conduit within the station and for at least 3 m (10 ft) beyond the ground grid or the power station perimeter fence."
- IEEE 789 – "It is important that metallic conduits should not be used or extended outside the station grid."
- Specific telephone company requirements at power stations (customer handout) – "Schedule 80 PVC conduit (suitable for cable pulling) from the HVP [High Voltage Protection] location to a point 10 feet (3 m) beyond the substation fence or ground grid."
- Some telephone companies also specify the use of lightning arrestors for these installations.
- Any high voltage protection and/or fiber optic equipment to be installed at the IPP/telephone company demarcation point will require power supplied by a maintained and monitored battery or UPS system.

1.14 SCADA

A SCADA remote terminal unit (RTU) shall be required for installations connected at 69 kV or 138 kV. The purpose of the SCADA RTU is to allow PPL EU to remotely determine the following:

- Status of all circuit breakers and motor-operated switches between the customer's point of contact and the generator(s). This would include:
  - the high side MOD which separates the customer's facilities from the PPL EU system,
  - the POC (Point of Contact) breaker,
  - the GSU (Generator Step Up) transformer high side breaker,
  - the GSU transformer low side breaker, if present, and
  - the generator breaker
- Status of the generator Automatic Voltage Regulator (AVR)
- Status of the Power System Stabilizer (PSS) if one exists
- Three-phase megawatts and megavars on the high voltage side of each GSU transformer
- Three-phase megawatts and megavars for each station service transformer
- Three-phase megawatts and megavars at each of the generators

- Frequency at the IPP's collector bus
- Three phase voltage at the IPP's collector bus
- Hourly integrated megawatt hours delivered to the PPL EU system.
- Hourly integrated megawatt hours delivered to the generation facility.
- Status of the direct transfer trip and protective relay equipment. (Alarm condition of various pieces of equipment considered critical.)

A SCADA trip from PPL EU to the IPP facility will be required. At the IPP's option, any of the following devices may be operated (tripped) by this SCADA trip signal:

1. The transformer high side (POC) breaker
2. The transformer low side breaker
3. The generator synchronizing breaker (if different from 1 or 2 above).
4. The unit Master Fuel Trip device
5. The Turbine Master lockout device
6. The Turbine Stop valves

} UNIT TRIP SIGNAL

The intent of the SCADA UNIT TRIP SIGNAL is to isolate the generation from the PPL EU system, in the safest possible manner. At some locations, operation of the high side breakers may cause the generation to overspeed. The above optional trips are designed to allow for a more-controlled shut down of the generation, by eliminating the fuel flow, or energy source to the turbine BEFORE the breaker between the generator and PPL EU is opened. For these installations, the PPL EU SCADA UNIT TRIP SIGNAL will be used to provide the trip signal, but cannot trip circuit breakers directly. The IPP will provide a suitable interface relay from the PPL EU SCADA unit trip output to their equipment.

PPL EU will make a reasonable effort to identify the need for an RTU within the normal review phase of a proposed new IPP project. However, with system upgrades, addition of new IPPs in the vicinity or other operational concerns, existing IPPs may be required to install an RTU in order for PPL EU to improve the reliability of its supply lines.

PPL EU will supply specifications and typical drawings for the PPL EU SCADA equipment, as well as a listing of the various inputs and outputs. Analog data will be provided by digital meters connected to the SCADA by a suitable communication network.

IPP generation at 138 kV shall be required to install an additional RTU for PJM Internet-based SCADA. This option REQUIRES a fixed IP address and an "always on" internet connection. A 'dial-up' internet connection will not be suitable due to the random assignment of IP addresses.

NOTE: Wind parks tend to have many small generators over a large area. These facilities will only be monitored at the point of contact and the main high voltage circuit breaker.

SECTION 2 RESPONSIBILITIES

The list of IPP Responsibilities covered in the following pages provides the IPP with a list of activities that must be completed before the generation equipment can be operated in parallel with the utility system. ***These are NOT necessarily in project sequence.***

Obtaining the information listed from the IPP in a timely manner will aid PPL EU to facilitate the process of coordinating the installation of IPR and POC protection equipment at the point of Interconnection. Items below which refer to "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)" (which covers new installation requirements) will have the **POC** designation.

2.1 IPP RESPONSIBILITIES

	Description	Reference
☐	Call PPL EU Business Accounts Department to initiate process	Telephone No. 1-888-220-9991, menu option # 4
☐	Complete Application for Parallel Generation (for small projects), or the PJM forms for large projects.	PPL EU Application for Parallel Generation or the PJM Generation manuals
☐	Submit preliminary site drawings, including plan and elevation views, showing desired location and orientation of substation for PPL EU to provide design tensions for customer dead-end structure (if required)	
☐	Provide Letter of Intent prior to the start of PPL EU Engineering (small project), or PJM procedures for large project	PJM Generation manuals
☐	Return signed Electric Service Contract (may be required)	
☐	Submit customer proposed one-line diagram as described in the reference, to include POC protection for installations with high side circuit breakers.	Point of Contact Protection & Control Requirements (Section 5) and IPR Requirements (Sections 5 and 6)
☐	Submit preliminary control drawings and specifications for PPL EU approval ***prior*** to ordering equipment	Point of Contact Protection & Control Requirements, (Section 5), and IPR Requirements (Sections 5 and 6)
☐	Submit final control drawings incorporating required PPL EU changes for point-of-contact protection ***prior*** to ordering equipment	Point of Contact Protection & Control Requirements (Section 5)
☐	Submit CT/VT/meter location and drawings for Approval	Submit to the Supervisor, Meter Engineering for review and acceptance
☐	Complete transformer data sheet and	Transformer Data Sheet and Physical

	submit transformer drawings for review ***prior*** to ordering (kVA, connection, taps, impedance, primary/secondary voltages)	& Electrical Design Requirements (**POC** Section 4)
☐	If applicable, inform PPL EU when POC and IPR relays are available for testing/setting	NOTE: PPL EU removes these relays for bench testing
☐	Supply slide bar lock on substation gate and disconnecting device	
☐	Submit switch, interlock schematic & details	Physical & Electrical Design Requirements (**POC** Section 4)
☐	Return signed Electric Service Contract prior to the start of PPL EU construction (small projects); large projects are through the PJM process.	
☐	Provide payment of costs to PPL EU for 69 kV or 138 kV service	
☐	Execute Right-of-Way agreement for transmission line easement	
☐	Submit final substation site location and orientation horizontal and vertical survey control points, and phase orientation of transformer	Physical & Electrical Design Requirements (**POC** Sections 1 and 4)
☐	Submit final control drawings incorporating required PPL EU changes for point-of-contact protection ***prior*** to connection to PPL EU system	Point of Contact Protection & Control Requirements (**POC** Section 5)
☐	Provide power transformer certified test reports for compensated metering (%) exciting current, % impedance, core loss, full load copper loss)	Physical & Electrical Design Requirements (**POC** Section 4)
☐	Provide Bill of Material (major electrical equipment only)	Physical & Electrical Design Requirements (**POC** Section 4)
☐	Provide Relay Test with a commissioning plan	See Relay Test Procedures, Section 7 of this document
☐	Inform PPL EU when point-of-contact relays are available for testing/setting	
☐	Call PPL EU when ready for PPL EU billing metering (separate from POC equipment) CT/VT delivery	Coordinate through the Supervisor, Meter Engineering
☐	Install PPL EU billing metering CTs and VTs per PPL EU specifications	Obtain specifications from the Supervisor, Meter Engineering
☐	Provide substation ground grid resistance test report per IEEE Standard 81.	Physical & Electrical Design Requirements (**POC** Section 4)
☐	Provide insulation test results for all 69 and 138 kV	

equipment up to and including point-of-contact protection device

☐ Complete inspection requirements - independent electrical final one-line diagram. This includes all PPL EU required station and equipment inspections.

☐ Provide as-built drawings for PPL EU file

☐ Provide proof all POC and IPR protection is functional and tested prior to the energization of the facility.

For all generation installations (but especially the small residential installations with inverters) it is the responsibility of the IPP/customer and their engineer/electrician to determine if the operational voltage limits of the IPP/customer's equipment (such as the inverters) will be exceeded at the maximum operational output of the generation during normal operation of the PPL EU system. It should be recognized that at certain times of the year, the PPL EU system voltage will approach the maximum limit as measured at the meter base of 126 or 252 volts. The addition of generation can cause this voltage to increase, or if there is a sufficiently long branch circuit to the generation equipment, the voltage at the IPP/customer's equipment (such as inverters) may be high enough for the IPP/customer's equipment (such as inverters) to trip off on over-voltage. It is the IPP/customer responsibility to take the possible voltage rise into consideration in the design of their facility.

2.2 METERING, IPR RELAYING AND SCADA RTU RESPONSIBILITIES

The matrix below indicates responsibilities relating to metering equipment, IPR/DTT relaying and the SCADA RTU:

RESPONSIBILITY	METERING (69kV or 138kV)	METERING (230kV or 500kV)	IPR/DTT RELAYING	SCADA RTU
Purchasing	IPP/Customer	IPP/Customer	IPP/Customer	IPP/Customer
Specifying	PPL EU [3]	PPL EU [3]	IPP/Customer [1]	PPL EU
Installing	IPP/Customer [4]	PPL EU [3,5] (Preferred)	IPP/Customer	IPP/Customer
Commissioning	IPP/Customer	PPL EU [3,5] (Preferred)	IPP/Customer [2]	IPP/Customer
Owning	PPL EU [3,4,6] (Preferred)	PPL EU [3,5,6] (Preferred)	IPP/Customer	IPP/Customer
Maintaining	PPL EU [3,4,6,7,8] (Preferred)	PPL EU [3,5,6,7,8] (Preferred)	IPP/Customer [7,8]	IPP/Customer [7,8]
Controlling	PPL EU [3,4,6] (Preferred)	PPL EU [3,5,6] (Preferred)	PPL EU [9]	IPP/Customer

[1] The IPP/Customer shall select IPR relaying from a list of PPL EU **Approved Customer Point of Contact and Generator Intertie Protective Devices**.

[2] PPL EU shall review the IPP/Customer relay settings to ensure optimal coordination is maintained with the PPL EU system. PPL EU shall witness IPP/Customer testing,

[3] Although PPL EU prefers to own, maintain and control the metering equipment (CTs, PTs and meter), PJM provides the IPP/Customer the option to assume these responsibilities. Regardless of whether the IPP/Customer decides to own, maintain and control the metering equipment or not, PPL EU shall always specify the metering equipment.

[4] For 69kV and 138kV metering installations, the metering equipment shall be installed inside the IPP/Customer substation. Regardless of whether the IPP/Customer decides to own, maintain and control the metering equipment or not, the IPP/Customer shall always own, maintain and control the installation (mounting, primary connections, conduit, secondary wiring, enclosures, etc.) of the metering equipment. The metering equipment shall be installed on the high side of the IPP/Customer transformer(s) before the high side FID(s).

[5] For 230kV and 500kV metering installations,

- If the IPP/Customer decides to own, maintain and control the metering equipment, then the metering equipment shall be installed inside the IPP/Customer substation. The IPP/Customer shall also own, maintain and control the installation (mounting, primary connections, conduit, secondary wiring, enclosures, etc.) of the metering equipment. The IPP/Customer shall also commission the metering equipment. The metering equipment shall be installed on the high side of the IPP/Customer transformer(s) before the high side FID(s).

- If PPL EU owns, maintains and controls the metering equipment, then the metering equipment shall be installed inside the PPL EU substation. PPL EU shall also own, maintain and control the installation (mounting, primary connections, conduit, secondary wiring, enclosures, etc.) of the metering equipment. PPL EU shall also commission the metering equipment.

[6] If PPL EU owns, maintains and controls the metering equipment (CTs, PTs and meter), then the IPP/Customer shall still be responsible for all operating costs associated with these responsibilities performed by PPL EU. Normal costs are bi-annual metering equipment testing, troubleshooting metering equipment and communication (cellular, DNP, KYZ pulses, etc.) issues, and other maintenance.

[7] The IPP/Customer shall contact PPL EU prior to performing any maintenance on the metering, IPR/DTT relaying or SCADA RTU equipment.

[8] The IPP/Customer may be responsible for any costs associated with PPL EU support for activities initiated by the IPP/Customer.

[9] PPL EU requires all IPR relaying equipment to be installed inside a dedicated cabinet with a latching door suitable for a PPL EU locking device.

2.3 COMMUNICATION CHANNEL RESPONSIBILITIES

The matrix below indicates responsibility relating to the DTT and SCADA RTU communication media type and equipment:

RESPONSIBILITY	TELEPHONE	DIRECT FIBER (69kV or 138kV)	DIRECT FIBER (230kV or 500kV)	RADIO
Purchasing	IPP/Customer [1,2]	IPP/Customer [2,3]	IPP/Customer [2,3]	IPP/Customer [4]
Specifying	PPL EU	PPL EU	PPL EU	IPP/Customer [4]
Installing	IPP/Customer [5]	IPP/Customer [3]	IPP/Customer [3]	IPP/Customer [5]
Commissioning	IPP/Customer [6]	PPL EU [7]	PPL EU [7]	IPP/Customer [6]
Owning	IPP/Customer	PPL EU [9]	IPP/Customer [8]	IPP/Customer
Maintaining	IPP/Customer [10,11]	PPL EU [9,10,11]	IPP/Customer [8,10,11]	IPP/Customer [10,11]
Controlling	IPP/Customer [12]	PPL EU [9]	IPP/Customer [8]	IPP/Customer [12]

[1] The IPP/Customer shall also be responsible for all costs associated with the leasing of the telephone lines and resolving any problems with the telephone service provider.

[2] The IPP/Customer shall contact PPL EU prior to purchasing any equipment.

[3] The IPP/Customer shall be responsible for the portion required to interconnect with the PPL EU fiber system. PPL EU shall witness all installation performed by the IPP/Customer.

[4] The IPP/Customer shall contact PPL EU prior to purchasing or specifying any equipment.

[5] The IPP/Customer shall also be responsible for installing all communication equipment at the PPL EU facilities. PPL EU shall witness all installation performed by the IPP/Customer.

[6] The IPP/Customer shall perform end-to-end testing, from IPP/Customer communication equipment to PPL EU communication equipment, with support from PPL EU. PPL EU shall witness all testing.

[7] PPL EU shall perform end-to-end testing from the PPL EU substation fiber splice box to the IPP/Customer substation fiber splice box, with support from the IPP/Customer. The IPP/Customer shall witness all testing.

[8] The IPP/Customer shall own, maintain and control all communication equipment up to the PPL EU substation fiber splice box, including the portion along the generator lead line. PPL EU recommends all communication equipment have locking provisions wherever necessary.

[9] PPL EU shall own, maintain and control all communication equipment up to the IPP/Customer substation fiber splice box, including the portion along the generator lead line. PPL EU recommends all communication equipment have locking provisions wherever necessary.

[10] The IPP/Customer shall contact PPL EU prior to performing any maintenance on the communication equipment.

[11] The IPP/Customer may be responsible for any costs associated with PPL EU support for maintenance activities initiated by the IPP/Customer.

[12] The IPP/Customer shall also control all communication equipment at the PPL EU facilities. PPL EU recommends all communication equipment have locking provisions wherever necessary.

SECTION 3 PPL EU TRANSMISSION LINE REQUIREMENTS FOR 69 KV OR 138 KV SUPPLY

Refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", Section 3, for additional information on dead-end structure requirements, spacing, cables/wires, etc.

SECTION 4 SUBSTATION PHYSICAL ELECTRICAL AND EQUIPMENT REQUIREMENTS

4.1 SUBSTATION ORIENTATION AND PPL EU TRANSMISSION LINE

The location and orientation of the customer-owned substation must be coordinated with the PPL EU Transmission Line requirements of Section 3, above.

4.2 SUBSTATION LINE DEAD-END STRUCTURE

The customer shall provide a suitable free-standing or guyed structure to terminate PPL EU's line(s). The structure can be steel, aluminum or wood and shall be designed to accommodate the tension and clearance requirements of the transmission line(s) as noted in Section 3 (above).

Parameters for terminating the transmission line must be obtained from Transmission Engineering before the customer commits to a design for the dead-end structure.

4.3 GROUNDING REQUIREMENTS

Refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", Section 4.3, for additional information on IPP facility grounding requirements. At a minimum, the grounding requirements will meet IEEE Standard 80, "Guide for Safety in AC Substation Grounding", latest revision, for step and touch safety requirements.

4.4 GROUND GRID TESTING

The customer shall have the substation grounding system tested for "resistance to remote earth" prior to making connections to the PPL EU lines and energizing the facility. The customer is responsible for arranging the test(s) and costs associated with such work. The tests shall be made in accordance with the "Fall of Potential" method as outlined in IEEE Standard 81, "Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System," latest revision.

All tests shall be conducted before any PPL EU shield wires, counterpoises and/or system neutrals are connected to the facility. If any external neutrals are connected before conducting ground testing, the results will yield false, lower value readings. Neutral(s) of any temporary construction power services must be properly isolated from the substation grounding system before tests are made. The test circuit configuration shall be so arranged that no "sneak circuits" exist through the measurements.

The reference "current probe" (C2) must be driven at a point beyond the "extent" of the ground system under test to obtain meaningful results.

All ground resistance test results must be submitted to PPL EU for approval and must include:

4.1 Geometry of the test circuit showing relative positions/directions and distances between test and reference electrodes. An accurate sketch or field-marked location plan drawing is acceptable.

4.2 Actual resistance measurements at several reference points including the "theoretical 62% point." Measurements shall be submitted as tabled values and graphically to illustrate the "plateau" and inflection points in the resistance curve.

PPL EU requires the effective resistance to remote earth of the customer's substation ground grid to be **five (5) ohms** or less.

4.5 POINT OF CONTACT SWITCHING DIAGRAMS AND NOTES

Refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", Section 4.5, for additional information.

4.6 EQUIPMENT AND MATERIAL

4.6.1 Power Transformers

The customer's power transformers **must have WYE connected, grounded primary windings, with neutral insulation suitable for impedance grounding.** This requirement is for customers with parallel generation; if an existing customer has NO Generation, the requirements are covered in the PPL EU document titled "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)". Existing load customers who are connecting generation may be required to install additional protection equipment due to the high side delta connection of the existing transformer.

The IPP or customer must contact PPL EU prior to ordering or specifying the main power transformer. Depending on the size, location on the PPL EU system, and other concerns, an alternate winding configuration may be specified.

Connection arrangement of the secondary windings is the customer's option, but must be reviewed with PPL EU to ensure PPL EU System protection and coordination are adequate.

The voltage taps should accommodate the voltage criteria discussed in Section 1.7, of the PPL EU document titled "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)". The PPL EU representative may be contacted to provide transformer tap recommendations prior to purchase and a desired tap setting at the specific location given the customer's load characteristics.

4.6.2 Point-of-Contact Circuit Interrupting Devices (CID) - Switches and Interrupter Accessories

Refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", Section 4.6.2, for additional information. In all situations, the equipment must be capable of interrupting expected current flows.

4.6.3 Point-of-Contact Fault Interrupting Devices (FID)

Refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", Section 4.6.3, for additional information. In all situations, the equipment must be capable of interrupting the maximum expected fault duties expected at the facility, which may be different from the actual present data.

4.6.4 Insulator and Surge Arrester

Refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)", Section 4.6.4, for additional information. In all situations, such equipment must comply with PPL EU Insulator coordination and Surge Arrester protection requirements.

4.6.5 Fault Currents

PPL EU 138-12 kV and 69-12 kV substations are designed to withstand fault currents of 20,000 amps. PPL EU recommends that customer switchgear and equipment be designed to handle this amount of fault current as a minimum. Contact PPL EU for actual fault duties at the customer's supply location.

If the customer elects to design equipment to meet a lower maximum fault current than the 20,000 amps recommended above, it must at least meet the calculated fault duties supplied by PPL EU for the customer's location, plus a suitable margin. Future system changes to the supply system may increase the fault duties at the customer's location and any upgrades required to meet these increased fault duties will be at the customer's expense.

SECTION 5 PROTECTION AND CONTROL REQUIREMENTS

Also refer to the PPL EU document, "Point of Contact Requirements for Transmission Voltage Customer-Owned Facilities (138 kV & 69 kV)**"** for additional details.

5.1 BACKGROUND

The functional characteristics designed into intertie protection schemes for customer-owned generators being connected to the existing PPL EU system are:

- Fast operation by under-voltage protection to disconnect the IPP's facility for a supply line fault or isolation prior to the first instantaneous reclosure. This is required to prevent the generation from possibly sustaining the fault and thus causing the line test from the PPL EU remote terminal to be unsuccessful or to minimize the chance of an out-of-phase reclosure.

- Fast operation on overvoltage protection if overexcitation and/or ferro-resonance cause a rapid, severe voltage rise.

- For smaller units, a simple, reliable, fail-safe system is considered important. The main emphasis is to assure disconnection on loss of the PPL EU source line. It is desired that tripping be initiated as directly as possible from the measured supply voltage with minimum reliance on interspersed devices. An AC powered, non-latching contactor is a suitable device.

- The interconnection relay system shall have the capability to withstand electromagnetic interference (EMI) environments (as per IEEE Std. C37.90.2-latest version) so that the influence of EMI shall not result in a change of state or misoperation of the interconnection system.

NOTE: Under no circumstance are the IPR relays to trip through a PLC (programmable logic controller) or other programmable device. The IPR must trip directly to avoid any additional time delay for an interposing programmable device. Auxiliary relays can be used only IF ABSOLUTELY necessary. The trip signal may be MONITORED by a PLC or other programmable device to facilitate control functions at the IPP facility.

5.1.1 Relays - Basic Package

- The intertie protective relay is intended to provide the same functionality as defined in IEEE 1547, the latest version.

- Large units, while interconnected, can have an appreciable impact on system voltage levels. Also, with more sophisticated controls it is more probable that larger units may continue operating if isolated with a portion of the PPL EU system. There is a need for a precise reactive power or voltage schedule and for a control system which prevents excessive deviation from the developed voltage schedule.

- Obtaining selectivity, to prevent false trips, for system faults not on the PPL EU source line takes on greater importance. Unnecessary tripping of these larger units can have a negative impact on the PPL EU system. **High speed reclosing typically will not be used on these supply lines.**

- Larger units can impact a significant portion of the power system, and therefore, a high assurance is required to clear the generator for trips of the PPL EU supply line to which it is connected.

5.1.2 Synchronous Generators - General

Synchronous generation facilities will require a dedicated Parallel Generation protection (IPR) intertie protective relay.

5.1.3 Induction Generators - General

Induction generation facilities will require a dedicated Parallel Generation protection (IPR) intertie protective relay.

If a capacitor is used to serve as the excitation source for an induction generator, the capacitor must not be capable of remaining on the system with the generator off line.

5.1.4 Inverter-based Interconnections

Inverter based installations using UL 1741 listed inverters will not be required to provide an additional disconnect switch at the meter location. NOTE: there may be other disconnect switches required by NEC or local electrical inspection requirements.

The designs of the inverters, especially the large inverters (above 10kW), is changing rapidly. Below is a list of items that may need to be addressed depending on the specific application.

Inverters convert DC power to AC by means of electronic switching. Switching can be controlled by the AC voltage of the supply system (line-commutated) or by internal electronic circuitry (forced-commutated), or the type PWM (Pulse Width Modulation). Line-commutated inverters are generally not capable of operating independently of the AC supply system and, as such, cannot supply fault current or isolated loads. Forced-commutated and PWM inverters are capable of supplying fault current and may supply load independent of the AC supply system. All inverters will be expected to conform to the ANSI/IEEE 1547 Standard for Interconnecting Distributed Resources with Electric power Systems (latest version) and UL Publication 1741-Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources (latest version).

Equipment like Solar arrays (photovoltaic), certain wind turbines, and microturbines, for example, generate their power at DC or high frequency AC and use inverters to convert this power to 60 Hz AC at a suitable voltage level.

- Units below 10 kW, which are in compliance with IEEE 1547, and UL-1741, can be connected to the PPL EU system without any other additional protection.

- Facilities rated 10 kW up to 2 Mw, or locations using multiple inverters will be subject to PPL EU review, and may require additional external protection (IPR) equipment.

The IEEE 1547 standard is primarily intended to be applied at the Area Electric Power System (EPS) or the utility DISTRIBUTION system, see IEEE 1547, section 1.3 limitations. ***Further ALL of the requirements of this standard are to be met at the PCC (Point of Common Coupling), which on the PPL EU system is typically the 12.47 kV, 69 kV or 138 kV connection to the IPP equipment, see IEEE 1547, section 1.2 Purpose, second paragraph.***

5.1.5 General Requirements

With the above background information, **the following items need to be discussed on all IPR projects:**

1. IPP generation facilities connected to the PPL EU 69 kV or 138 kV systems will typically be required to have DTT (Direct Transfer Trip) installed to the PPL EU substation supplying the 69 kV or 138 kV source line. This is to ensure that the IPP's generation is quickly disconnected from the PPL EU system for PPL EU supply line faults and to limit interference with existing PPL EU under-frequency schemes.

2. These facilities will be required to have POC (Point of Contact) protection and IPR (Intertie Protection Relay) protection. Care must be exercised if choosing fuses for the 69 kV high side protection as under some circumstances, the IPP fuses may operate before PPL EU relaying for faults on the PPL EU system. PPL EU strongly recommends the use of a three-phase fault isolation device (circuit breaker or recloser).

3. The IEEE 1547.1 tests and the UL 1741 tests only test the operation of the inverter at THE TERMINALS OF THE INVERTER. However, the application of LARGE PV requires the use of one or more transformers to get from the low voltage inverter output (120 to 600 VAC) to the utility 69 kV or 138 kV supply voltage level. The inverters may not correctly control or maintain the required settings at the PCC as they do not have a direct connection (sensors, CTs, or PTs) to the PCC. See IEEE 1547, section 1.2, second paragraph, which states "The requirements shall be met at the point of common coupling (PCC), although the devices used to meet these requirements can be located elsewhere." Per IEEE 1547.1 Testing Requirements, section 5.2 "If the EUT senses voltage at a different point than the PCC with the area EPS or at the point of DR connection as specified in IEEE Std 1547, it shall be tested under load in conjunction with any external isolation transformer supplied or required by the EUT manufacturer." The IPP or the inverter vendor needs to provide additional information on this item.

4. The IPP or the inverter vendor is requested to supply a copy of the UL1741 test report as well as any documentation of the effects or interactions of multiple units operating in parallel on the IEEE settings and operating times.

5. At larger facilities, high voltage CTs and PTs (or CCVTs) will be required for the POC, IPR relaying as well as the PPL EU SCADA and revenue metering. In some cases the PTs (or CCVTs) can be supplied with dual windings to support both the protection equipment as well as the revenue metering requirements. Separate CTs will be needed for protection and metering.

   ATTENTION: PTs or CCVTs at the 69kV and 138kV voltages located on the PPL EU side of the POC circuit breaker MUST have adequate high voltage fusing to protect PPL EU transmission facilities from equipment failure.

6. The IPP or the inverter vendor will need to comment on the capability of the proposed equipment to REGULATE the power factor of the overall facility as measured at the PCC per PPL EU requirements. The equipment will need to be able to adjust the var flow with respect to the real power level. Also, since these facilities are typically LINE connected, they will typically be required to ABSORB vars to maintain the correct line voltage at the PCC. While IEEE 1547 section 4.1.1 states “The DR shall not actively regulate at the PCC. The DR shall not cause the area EPS service voltage at other local EPS’s to go outside the requirements of ANSI C84.1-1995, range A.”, the second sentence will typically be the requirement for LINE connected facilities.

7. The IPP must provide a one line with sufficient detail to show all transformer connections, and the location and connection of all of the above equipment.

8. The IPP must supply full electrical specifications for all electrical equipment included in the POC and IPR requirements (as well as inverters), including but not limited to the fault current levels and duration.

9. PPL EU employs automatic reclosing on its electrical systems. The initial reclosure is typically delayed 1.5 seconds at the 69 kV and 138 kV voltage levels. Both of these are much faster than the IEEE 1547 anti-island settings of 2 seconds. The IPP or the inverter vendor must provide data or other information on the potential out-of-phase reclosing that could potentially exist with other customer’s rotating equipment connected to this area EPS. PPL EU will typically modify its facilities to include syncheck relaying to avoid out-of-phase reclosing.

   NOTE: The above items are specific technical issues identified for conventional generation as well as some special requirements for inverter-based equipment. PPL EU will notify the IPP via the Method of Accommodation (MOA) or Method of Supply (MOS) documents of any other requirement(s) which may be necessary (such as SCADA, DTT, metering equipment, telephone lines and other protection or communication equipment) after a detailed assessment

The inverter installation must be designed such that an interruption to the PPL EU supply line will result in the disconnection of the inverter to the supply system.

Since this feature is normally included in the inverter interface, additional intertie protective relaying will not be required for certified system 10 kVA or less. This equipment is required to conform to IEEE Standard 1547, latest version, and UL Publication 1741, latest version. In order to verify conformance with this requirement, PPL EU must be provided with sufficient information on the interface package. Harmonics and distortion of the voltage or current, generated by the generator-inverter combination, must not exceed PPL EU harmonic distortion requirements, as per IEEE Std. 519, latest version. Under no circumstances will these installations be allowed to inject DC current above the IEEE 1547 limits in to the PPL EU system.

Due to the rapidly changing products for providing various protection requirements, the IPP and PPL EU will discuss current offerings, and come to an agreement on one or more suitable devices. Prepackaged IEEE 1547 certified generators will be accepted as meeting the requirement for various voltages, frequency, and other included protective functions.

Generation equipment certified to IEEE 1547 will provide sufficient protection for most installations. Occasionally the generation will have such a large impact that the PPL EU equipment cannot be coordinated with the generation facility, or the generation facility can support operation as an island. Under these circumstances, additional protection beyond that specified in IEEE 1547 in the form of DTT or voltage block closing, or both may be required.

5.1.6 Temporary Installations:

Temporary installations are those installations where the generation is rented or installed for specific period of time, and is not permanently connected to the PPL EU system. This generation is also subject to being removed and replaced with different equipment. This generation is usually installed in a campus type setting and is usually limited to less than 200 hours of operation per year.

The following items should be considered for these applications:

1. The IPR relaying should be installed in such a manner that it will NOT need to be removed or re-installed with the generation.

2. Consideration should be given to limiting or eliminating the connections between the generator controls (tripping, closing, and auxiliary switches), and the use of a single breaker to isolate multiple generators.

3. IEEE 1547 requirements should be met by the relaying, independent of the generation installed.

4. The entire design of the facility should take in to consideration the probability of changing out the generation equipment on a yearly basis WITHOUT the need to make changes to the PPL EU required IPR cabinet.

5.1.7 Installations Interconnected with the 69 kV System and above

Generation facilities connected at 69 kV or 138 kV will require DTT to be installed to provide fast tripping of the generation facility for supply line faults. Local IPR relaying will provide a backup tripping function should the DTT fail to operate during the fault.

The primary method of tripping large generators on loss of the PPL EU supply line is by telephone line-based dual-channel Direct Transfer Trip or an equivalent fiber optic-based or radio-based point-to-point communication circuit. The tripping signal to the IPP's facility is initiated by either of the following two schemes at the remote PPL EU supply substation:

- the supply line protective relays, and/or
- opening of the supply line breaker

5.1.8 Generator Relay Settings

PPL EU will request specific setting information on any generation relays, which will act to trip the generator. The purpose of this request is to review the generation settings to ensure proper coordination of the generation relays with PPL EU operating practices. It is, however, the responsibility of the generator owner to apply generator protective relay settings that will provide adequate generator protection to meet IEEE guidelines and other regulatory body requirements.

5.1.9 PPL EU Control Switch

All installations must include a PPL EU control switch (PCS) located on the intertie protective relay cabinet. The PCS must be wired to trip the generator isolation breaker and to block closing in the "Normal-After-Trip" position. The PCS shall be wired to permit closing only when placed in the "Normal-After-Close" position, but it shall not close the breaker directly.

5.2 GENERAL – CTs, VTs, METERING, ETC.

For all single-phase and three-phase installations greater than 100 kVA, location for the source of relay and revenue metering potentials and currents shall be on the high side of the generation power transformer(s) before the high side FID(s). For all single-phase and three-phase installations up to 100 kVA with a fused point-of-contact where use of high-side VTs and CTs is uneconomical or impractical, these devices may be located on the low-side of the generation power transformer. However, this configuration must be reviewed and accepted by PPL EU (for the revenue metering, specifically reviewed and accepted by the Supervisor of Meter Engineering) and, in general, will only be permitted if service to other PPL EU customers will not be impacted.

All installations must include:

- An ammeter (for single-phase installations), or an ammeter and a switch to monitor all three phases (for three-phase installations), or suitable 3-phase digital display

- Where a PPL EU SCADA is to be installed, a digital multi-function meter, transducer, or relay is required. This device will be used to collect the analog data for the SCADA, and to provide local readings. **Contact PPL EU for current equipment requirements.**

- A visible SEMAPHORE on each of the breakers between the generator and the PPL EU system to determine the actual status of the breaker (open or close).

To prevent a possible undesirable (out-of-phase) connection of the generation to the PPL EU system, synchronous generators will require a synchronism check relay (25). Induction generators require a voltage check relay (27). These devices must be located in the IPR cabinet and connected to prevent closing of the generator circuit breaker, or other breaker as agreed to by PPL EU, for:

- An out-of-phase condition.

- A de-energized line condition (PPL EU supply breaker open).

- A de-energized synchronous generator condition.

- An energized induction generator condition.

When a synchronism or voltage check relay is required, the IPP must install a relay accuracy class voltage transformer on the generator side of the generator breaker, or other breaker as agreed to by PPL EU, to supply potential to this relay.

For generation facilities which are subject to PJM approval, the customer must also ensure that the CTs and PTs used to provide PJM SCADA and metering information meet the PJM requirements as discussed in “PJM Manual 01: Control Center and Data Exchange Requirements”.

ATTENTION: Voltage Transformers at 69kV and 138kV, located on the PPL EU side of the POC circuit breaker MUST have adequate high voltage fusing to protect PPL EU transmission facilities from equipment failure.

5.3 MICROPROCESSOR-BASED RELAYS, PROGRAMMABLE LOGIC CONTROLLERS (PLCs), TRIPPING SOURCES AND REMOTE ALARMS

If the customer chooses multifunction microprocessor-based relays and programmable logic controllers to provide the POC and IPR protection and control of the substation, the following requirements must be met:

5.3.1 Multifunction Microprocessor-based Relays

Sources that supply microprocessor-based relays must be uninterruptible. (Relays which are powered from the current transformers and do not require separate power supplies are preferable.)

With the trend to using microprocessor-based relays, and the tendency to include all of the required IPR protection in a single device, failure of this one device must be considered. PPL EU strongly recommends that two (2) independent relays be provided, such that failure of the one relay will allow continued operation of the customer's facility until the failed relay can be repaired or replaced. **Failure of a single IPR relay installation will require the immediate disconnection of the customer's generation from the PPL EU system.**

Control logic included in a microprocessor POC relay shall not be used to provide control functions of the FID.

5.3.2 Programmable Logic Controllers

When customers choose Programmable Logic Controllers (PLCs) for control, all FID tripping must be accomplished via hard-wired control circuits and must operate independently of the PLC controls. This is required for trip functions from:

- IPR relays and POC relays (including differential and/or summation over-current relay schemes, if considered to be part of the POC protection package)
- Control switches—trip and closing functions
- Automatic source transfer schemes (such as are permitted at customer substations with two supply sources, including customer-owned generation)

PLC control schemes are permissible for automatic operations such as source transfers of the POC FIDs, but the PLC controls must be "backed up" or duplicated by hard-wired interlocks provided to prevent paralleling the utility supply lines.

5.3.3 Tripping Sources and Remote Alarms

- FID trip controls must be via DC supply.
- Provisions must be made to remotely monitor DC power sources, microprocessor-based relays, and PLC failures. In general, all device alarms (such as loss of AC potential, relay failure, loss of control power, battery charger alarms, etc.) should be connected to a central annunciator or monitoring panel. All IPR equipment alarms (whether indicating lights, annunciators, or horns/strobe lights), must be routed to a manned location where the alarm condition will be noticed and analyzed in a timely manner. PPL EU must be notified, and corrective actions planned, as soon as possible.

SECTION 6 CLASSIFICATION OF INSTALLATIONS

The following general classifications show the major operating characteristics and protection requirements for typical installations. Each classification gives a general review of the types of parallel connections expected for service on the PPL EU system. A summary of these classifications is shown below.

TYPE 1 Single-phase, 12 kV line connected, any type of generation, up to 200 kW. **[Not covered in this document. Refer to the PPL EU document, "Relay and Control Requirements for Parallel Operation of Distributed Generation (12 kV and below)"].**

TYPE 2 Three-phase, 12 kV line connected, any type of generation, up to 3000 kW. **[Not covered in this document. Refer to the PPL EU document, "Relay and Control Requirements for Parallel Operation of Distributed Generation (12 kV and below)"].**

TYPE 3 Three-phase, 69 kV or 138 kV radial-line connected, any type of generation, limit on generation based on system impacts.

TYPE 4 Three-phase, 69 kV or 138 kV and above network-line connected, any type of generation, limit on generation based on system impacts.

TYPE 5 Three-phase, any voltage level, allows a momentary parallel of less the 5 minutes, any type of generation, limit on generation based on system impacts.

TYPE 6 Three-phase, any voltage level, campus or facility type installations, with no intentional power flow into the PPL EU system.

TYPE 7 Direct substation or switchyard connected facilities. Typically involves very large facilities at 138 kV or above.

Applicable to all TYPES:

1. The visible break safety switch, as mentioned on page 13 under Section 1.3, must be lockable in the open position, and must be located between the generator and the PPL EU metering point to provide a visible break.

2. Contact PPL EU for specific metering requirements.

3. When more than one (1) breaker is installed between the generator and the PPL EU Point of Interconnection, the IPR relaying must trip one of the breakers between the generation and the PPL EU system. The choice of which breaker to trip will usually be determined by discussion between PPL EU and IPP personnel, considering the operation of the IPP's facility and PPL EU reclosing practices.

4. For all installations, the preferred relays are microprocessor-based units with multiple functions. These relays provide many of the above functions in one case as well as oscillographic and sequence of events capability. All microprocessor-based relays are

to be ordered with suitable ports and communication software to allow setting and transferring of data from a laptop computer.

5. For induction and synchronous generators, protection will be required to meet IEEE Std. 1547 requirements. At a minimum, this will require over/under voltage, over/under frequency, directional power and synch-check functions.

6. Inverter-based generators meeting IEEE Std. 1547/UL 1741 requirements are acceptable, up to the 200 kVA limit, without additional protection. However, if there are multiple inverters involved, then additional review will be necessary and may result in additional protection requirements.

7. AC powered shunt trips are not acceptable for tripping/isolating the generator unless an appropriate UPS unit is installed.

8. An AC undervoltage trip should be included on the generation isolation breaker if normal tripping is by a DC shunt trip.

TYPE 3

A Type 3 installation, shown in Figure 1, covers three-phase inverter, synchronous and induction generators connected to a radial or network 69 kV or 138 kV radial circuit. These installations are characterized as:

- The PPL EU line is a radial line.
- Being connected through a three-phase transformer (WYE connected high side, delta low side).
- Having a high-side circuit breaker (item C in Figure 1).
- Having a switch (POC switch), lockable in the open position, to block the generator from operation.

Relay Requirements

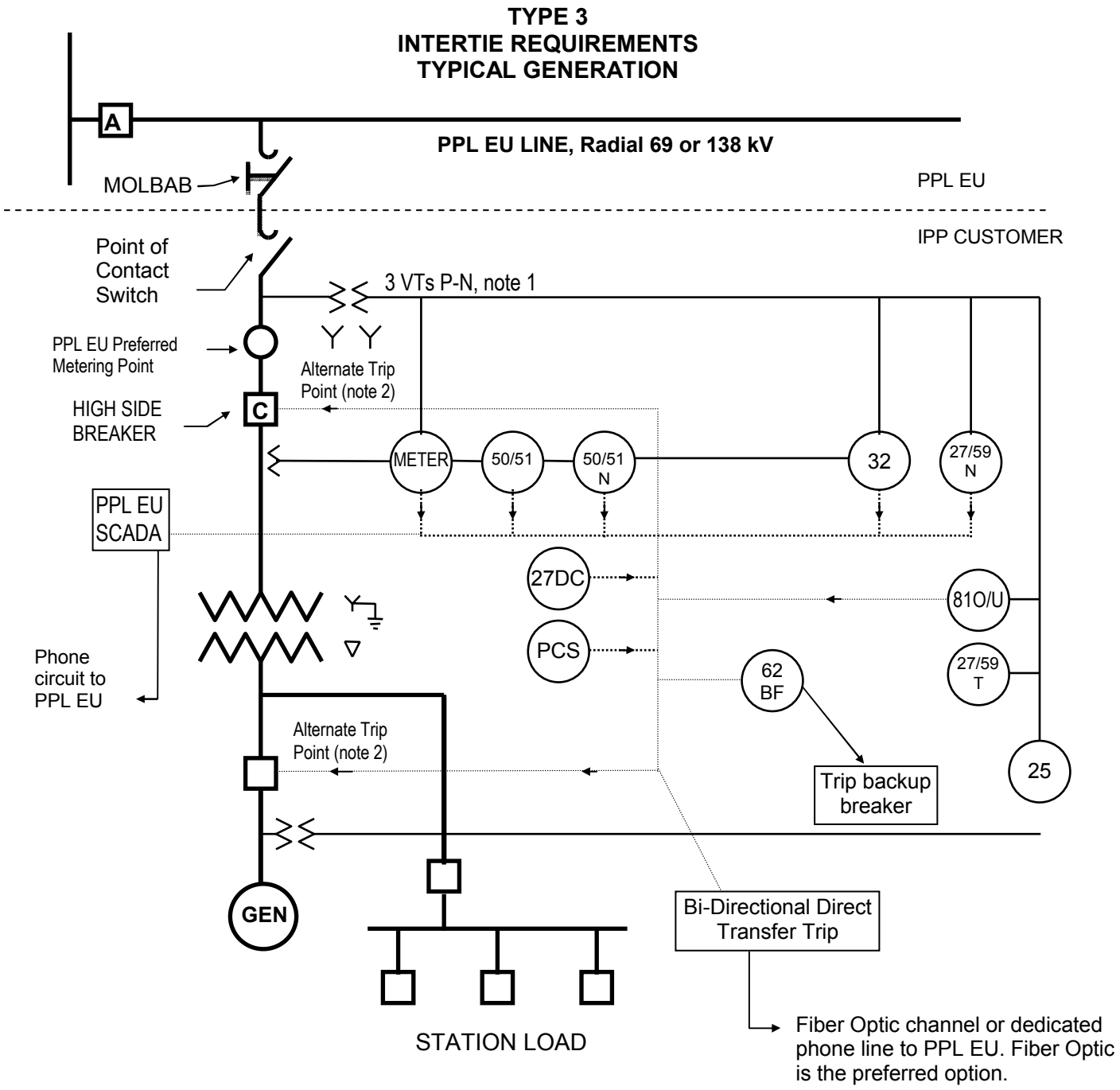
Type 3 installations require bi-directional direct transfer trip. The transfer trip will ensure fast tripping of the generator upon receipt of a trip signal from all remote sources. Accordingly, modifications will be required at the remote PPL EU substation.

Also, SCADA is required at these installations to allow PPL EU to remotely monitor electrical conditions at the generation site and to provide a means for PPL EU to remotely disconnect the generation from the power system in the event of a system emergency.

A determination of the requirements for DTT and the selection of the breaker to be tripped for generator isolation will be made after discussion between PPL EU and the IPP.

Notes on Figure 1:

- A three-phase voltage check relay supervises reclosing of substation CB "A." (This will delay reclosing until the generation is isolated. Reclosing will be approximately 1.5"-15"-15" after line is de-energized.)
- The main transformer must have a fully insulated WYE connected winding, on the high side, suitable for impedance grounding.
- A SCADA trip from PPL EU to the generator facility will be required. At the IPP's option, any of several allowable devices may be operated (tripped) by this SCADA trip signal: See Section 1.14.



Note 1: Fuses must be installed on customer VTs on the PPL EU side of the POC CB.

Note 2: Location of trip point to isolate IPP's generation to be discussed.

FIGURE 1
TYPE 3 IPR REQUIREMENTS

TYPE 4

A Type 4 installation, shown in Figure 2, covers three-phase inverter, induction or synchronous generators connected to the 69 kV or 138 kV networked transmission system. These installations are characterized as:

- The PPL EU line is a network line.
- Being connected through a three-phase transformer (WYE connected high side, delta low side).
- Having a circuit breaker (item C in Figure 2) as the intertie protective device.
- Having a draw-out type circuit breaker or a safety switch, lockable in the open position, to block the generator from operation.

Relay Requirements

Type 4 installations normally require bi-directional direct transfer trip to both PPL EU substations. The transfer trip will ensure fast tripping of the generator upon receipt of a trip signal from all remote sources. Accordingly, modifications will be required at both of the remote PPL EU substations.

Also, SCADA is required at these installations to allow PPL EU to remotely monitor electrical conditions at the generation site and to provide a means for PPL EU to remotely disconnect the generation from the power system in the event of a system emergency.

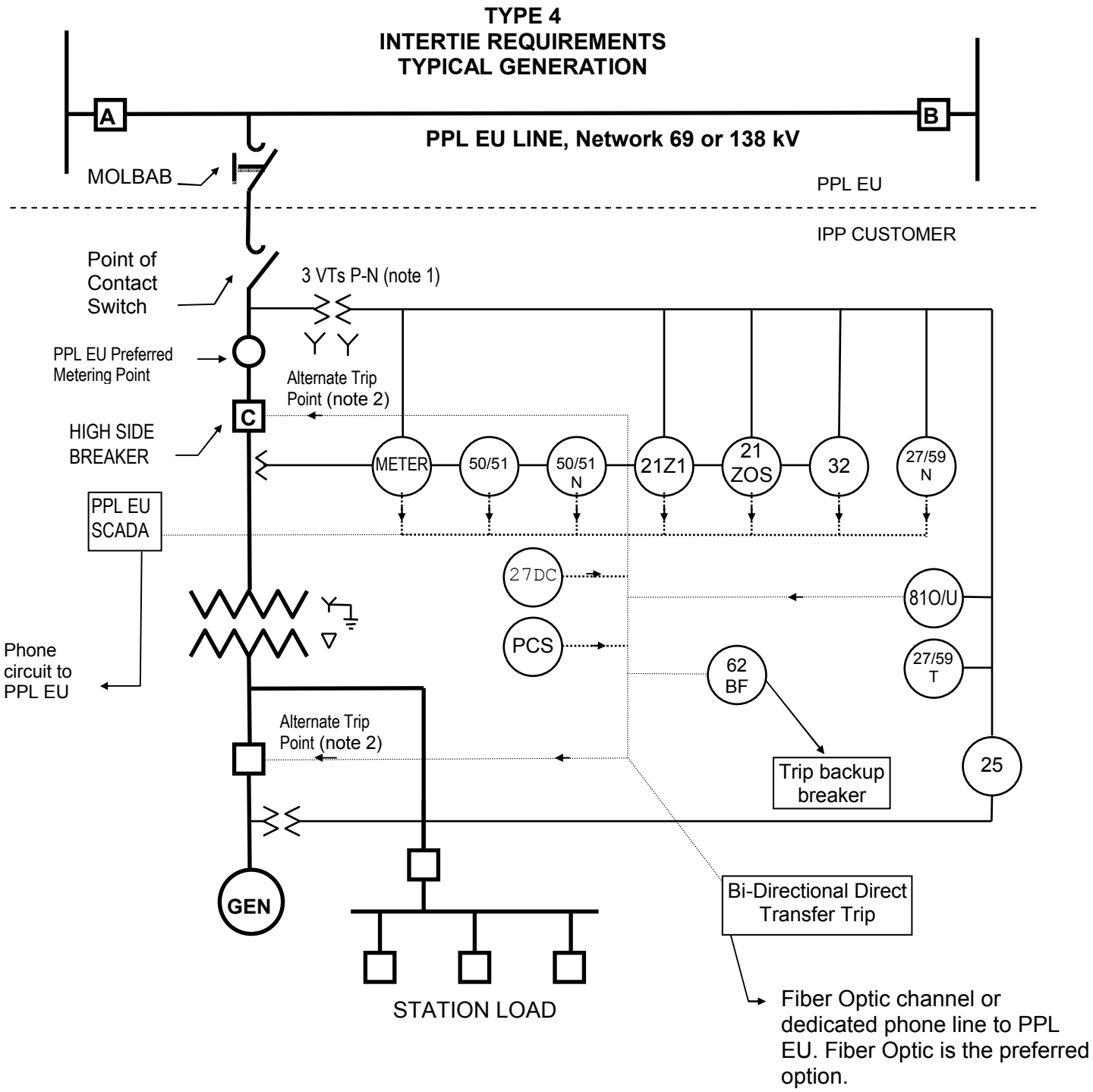
A determination of the requirements for DTT and the selection of the breaker to be tripped for generator isolation will be made after discussion between PPL EU and the IPP.

Notes on Figure 2:

- A three-phase voltage check relay supervises reclosing of substation CBs "A" and "B." (This will delay reclosing until the generation is isolated. Reclosing will be approximately 1.5"-15"-15" after line is de-energized.)

- The main transformer must have a fully insulated WYE connected winding on the high side, suitable for impedance grounding.

- A SCADA trip from PPL EU to the generator facility will be required. At the IPP's option, any of several allowable devices may be operated (tripped) by this SCADA trip signal: See Section 1.14.



Note 1: Fuses must be installed on customer VTs on the PPL EU side of the POC CB.

Note 2: Location of trip point to isolate IPP's generation to be discussed.

FIGURE 2
TYPE 4 IPR REQUIREMENTS

TYPE 5

In a Type 5 installation, the generation is allowed to parallel with the PPL EU system ***for a limited period of time (not greater than 5 minutes)***, but not send any power to PPL EU. The generation facility's load is always larger than the generation, and there will not be any excess power to send to PPL EU.

NOTE: This type is different from a make-before-break transfer switch. A make-before-break transfer switch is expected to parallel for less than 100 milliseconds, and generally does not have a failure mode that will maintain the parallel operation position of the switch. For applications involving transfer switches, contact PPL EU for approval of the proposed transfer switch.

The following requirements must be met (at a minimum):

1. The IPP will be required to supply an IPR cabinet with at least the following protective functions:
   - A synch-check relay supervises closing of CB used to parallel customer facilities with PPL EU system when the generator is operating. The need for synch-check supervision will be evaluated on a case-by-case basis and will depend on size of the generator and potential impact of an out-of-phase parallel on the PPL EU system.
   - An undervoltage relay for each phase, or a single three-phase relay
   - A sensitive reverse power relay (Connected to measure power ***into*** the PPL EU system at the utility/customer intertie location.)
   - A timer activated when the generation is paralleled, and connected to trip a breaker to separate the generation from the PPL EU system. Maximum time will be 5 minutes. Timer logic must be hardwired (not controlled with an electronic device such as a programmable logic controller).
   - PPL EU control switch and indicating lights
   - Ammeter and switch

   NOTE: Depending on the exact location, size, and type of generation, additional relays may be required. Intertie relays that initiate tripping of the generator need only be in service *when the generator is paralleled with the PPL EU system*.

2. Due to the minimal relaying, PPL EU will require a "Fail-Safe" AC powered undervoltage trip control scheme or a DC powered control shunt trip scheme with a backup AC undervoltage trip.

3. The generator will not be allowed to send any power into the PPL EU system.

4. The IPP must supply a complete set of drawings and system information for PPL EU review.

5. PPL EU will assume operational control of the relay(s), etc., in the IPR cabinet.

6. PPL EU will specify the time duration for which the generation will be allowed to operate in parallel with the PPL EU system.

7. A SCADA trip from PPL EU to the generator facility will be required. At the IPP's option, any of several allowable devices may be operated (tripped) by this SCADA trip signal: See Section 1.14.

TYPE 6

Campus type installations consist of one or more generators installed at various locations within a facility.

The TYPE 6 installation may be similar to any of the previous connections, BUT there *is never any power flow back to PPL EU*. These installations will contain one or more reverse power relays that will be connected and set to detect ANY power flow into the PPL EU system. When reverse flow is detected, a suitable device will be operated to immediately remove the generation from the PPL EU system.

These installations tend to be part of campus style installations, and therefore do not lend themselves to a standard design. The IPP is required to submit detailed one line drawings to discuss which devices will operate, and the locations of the various sensing components (CTs, PTs and the relaying). PPL EU will review the proposed design and comment as necessary.

The device to be used to isolate the generation will be determined through discussions between PPL EU and the IPP, depending on the operation of their facility.

Also, depending on the possible impact of the generation on the PPL EU system, additional functions as previously listed for TYPES 3 and 4 may be required in addition to the reverse power relay.

A SCADA trip from PPL EU to the generator facility will be required. At the IPP's option, any of several allowable devices may be operated (tripped) by this SCADA trip signal: See Section 1.14.

TYPE 7

This type consists of large generation units connected at 69 kV and above to a transmission or sub-transmission switching station where there is a very remote likelihood of isolating generation on load.

Type 7 installations will be large installations connected to the 69 kV through 500 kV PPL EU system. In general these facilities will be above 100 Mw in size, but may be smaller. These installations may consist of one or more smaller generators.

In general, 230kV and above lines on the Bulk Power System are connected in parallel (or network) operation and do not have customer load connected directly to the line.

Such installations will have the following characteristics:

- The generation will be connected by double-breaker or breaker-and-a-half terminations,
- Due to the normal system configuration, for an outage of a single facility, the generation is not isolated with PPL EU load.

Requirements:

In cases where generation facilities are connected to the 230kV and above system, they will be expected to install a full complement of primary and backup relaying as required for reliability by NERC, RFC and PPL EU. Relaying will be specified on a case-by-case basis.

Installations with multiple generators will need to apply out-of-step relaying on a per generator basis, directly on each generator. In general, it will not be practical to apply this protection in the IPR cabinet.

Installation with multiple generators will need to apply synch-check relaying on a per generator basis, directly on each generator. In general, it will not be practical to apply this protection in the IPR cabinet.

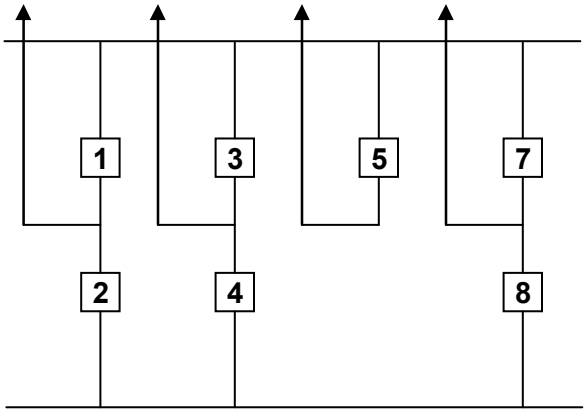
Generally, the Interconnection Protective Relaying cabinet will not need to contain special protection schemes to prevent accidental generation isolation on customer load, since such load is not directly connected to 230kv and above facilities. However, certain special protection schemes may be required on a case-by-case basis to comply with RFC and NERC reliability criteria.

A SCADA trip from PPL EU to the generation facility will be required. At the IPP's option, any one of several allowable generation isolation breakers may be operated (tripped) by this SCADA trip signal; see Section 1.14.

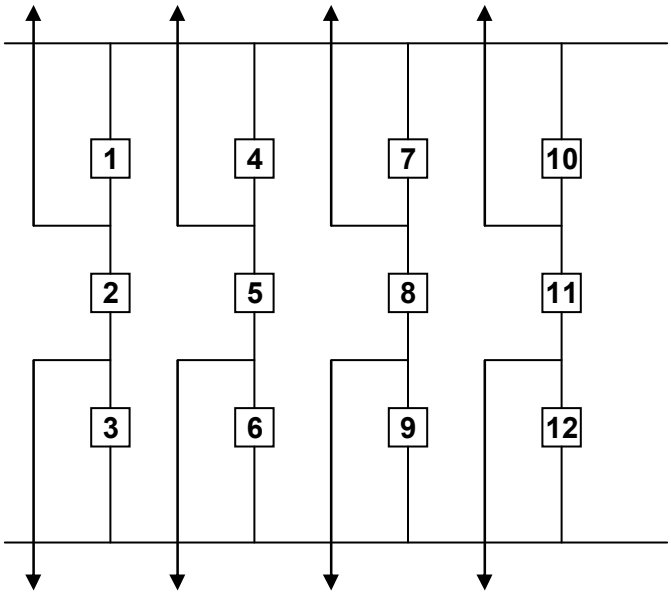
Below are typical switchyard connections:

These facilities are generally either double-breaker design, or breaker-and-a-half design. Examples of each are shown below for clarity.

Double-Breaker design:



Breaker-and-a-half design:



Contact PPL EU for additional information on these types of installations.

SECTION 7 RELAY TEST PROCEDURES

The Relay Test Department at PPL EU provides technical field support for all customer Point of Contact (POC) installations and Intertie Protective Relay (IPR) installations involving systems with protection relays. They should be included in the early review of customer POC and IPR systems, along with other key PPL EU groups, to help the IPP to develop an optimum and effective design.

As the POC and IPR work progresses to the physical construction stage, Relay Test will participate in an initial "on-site" job meeting to develop a work plan to support all issues of concern to Test which are required to connect the customer to the PPL EU system.

These include POC and IPR related protection equipment:

1) Relay acceptance tests and calibration of settings (issued by PPL EU Protection and Control Engineering)
2) Current Transformer tests
3) Current Transformer saturation tests
4) Current circuit verification
5) Potential circuit verification
6) Control circuit tests
7) In-service verification tests
8) Secure the relays form tampering by use of a software password or by applying a PPL EU seal, as applicable to the relay type
9) Plus any other issues related to the POC and IPR systems

PPL EU Relay Test personnel will complete items 1, 7 and 8. Items 2 through 6 can be done by the customer's contractor and witnessed by Relay Test employees, or completed by Relay Test with customer participation as appropriate.

PPL EU Relay Test personnel will require a written commissioning procedure proposed by the IPP's contractor. This procedure should cover a step-by-step listing of the tests required to ensure that the IPP's POC and IPR schemes operate properly. This commissioning procedure should be supplied to PPL EU at least two weeks prior to the scheduled in-service testing process. The IPP is to provide a detailed procedure for PPL EU review of the initial phase-out and synchronization. This must be reviewed prior to actual synchronization (generally only larger systems).

One of the responsibilities of the PPL EU Relay Test personnel is to secure the POC and IPR relays upon successful completion of the commissioning procedure. The IPR cabinet required to house the IPR relay packages will be supplied with a cabinet door suitable for securing with a suitable lock. In addition, the POC and IPR relays can be secured via use of passwords to limit access. The POC and IPR protection equipment is installed to protect the PPL EU system from adverse effects of the customer's equipment. For this reason, control of this equipment must remain with PPL EU.

Customers are billed for work done by PPL EU personnel outside of the "core working hours" should be made aware of this policy.

PPL EU will observe verification of the correct operation of synchronizing circuit, for synchronous units. The intent is to do this for all installations above 1000 kVA.

The generator operator is to verify the phase rotation of the generator. Please note that in MOST cases the PPL EU system rotation is C-B-A. The generator is expected to verify with PPL EU the specific rotation at their facility.

SECTION 8 DRAWING REQUIREMENTS

ALL drawings must be suitable to be scaled to "D" size (24 inches by 36 inches), except for reports, word or excel documents. Reduced size drawings are NOT acceptable.

8.1 DRAWINGS AND INFORMATION FOR REVIEW

Equipment that is IEEE 1547 compliant will have greatly reduced drawing requirements. It is expected that most if not all of the required protection will be built into the generation equipment. Under these circumstances, PPL EU will request copies of the manufacturer's drawings, and any drawings showing external inputs to the protective equipment, for example CTs or PTs. If the Generation operator has decided to operate a different breaker then that supplied with the generation equipment, the drawing showing the controls and interlocks to this breaker will also be requested.

PPL EU's Substation Engineering section will require the following drawings/information for review and acceptance:

NOTE: A final set of "as built" drawings are required to be submitted to PPL EU within 60 days of initial synchronization of the generation. Failure to submit such drawings may result in the generator not being able to interconnect with the PPL EU system until the "as built" drawings are received.

- One Line Diagram *
- Three Line Diagram
- Transmission Line Dead-End Structure (proposed/final)
- Plan and Elevation Views (electrical arrangements only)
- Grounding Plan and Details
- Ground Test Report (when customer substation is complete but before PPL EU supplies are connected) *
- Bill of Material (major electrical equipment only, including switch, protective device, transformer, surge arresters, relays, etc.) *
- Switch Interlock Schematic and Details
- Three Line Potential Elementary
- Three Line Current Elementary *
- Control Elementaries, each 69 kV or 138 kV FID *
- Power Transformer Certified Test Report(s)
- Front view showing POC Relay and Control Equipment *
- A detailed written description of Point of Contact (POC) and Intertie Protective Relay (IPR) protection and control functions and description of operation to include the following: *
    - Point of contact breaker or low side circuit breaker
    - Generator circuit breaker
    - Controls associated with the above circuit breakers
    - Any other equipment that connects to the above breakers
    - System interlocks
    - Direct transfer Trip equipment, if required
    - General description of the operation of the facility, including operational modes [parallel, isolated, peak shaving, etc.)
    - Any other unique facilities or operational modes

- High side breaker isolation procedure, if a SF-6 high side breaker is used
- Commissioning procedure *
- POC relay instruction book *
- POC CT saturation study *
- Auto transfer switch make and model (if customer-owned backup generation is installed)

* Denotes drawings which must be supplied for every type of customer facility. Other drawings must be supplied as applicable.

8.2 CONTENTS OF DRAWINGS

The customer's IPR (and POC) drawings shall contain the following information:

8.2.1 One Line Relay Diagrams

This drawing shows the customer's substation functional arrangement. All the equipment shall be shown using single-line diagram and standard symbol notations (per latest ANSI/IEEE Standard 315; titled Graphic Symbols for Electrical and Electronic Diagrams). This drawing shall include:

- Equipment names and/or numerical designations for main Fault Interrupting Devices (FIDs), air switches, power transformers, and associated POC relays and control devices shall be shown to match with PPL EU line designation. (Note: The required information will be provided by PPL EU after the customer submits a preliminary one line diagram.)
- Power Transformers - Nominal kVA, nominal primary/secondary and tertiary voltages, vector diagram and impedance.
- Instrument Transformers - Voltage and Current that supply the POC relaying.
- Lightning Arresters/Spill Gaps/Surge Capacitors - Ratings.
- Air Switches - Indicate status normally open with a (N.O), normally closed with a (N.C.) and type of operation manual or motor.
- Safety Switch - Continuous ampere and interrupting ratings.
- FIDs - Interrupting rating, continuous rating, operating times.
- Transformer Fuses - Size, type, manufacturer, location.
- Grounding.
- Generator(s) - Include type, connection, kVA, voltage, current, phasing, rotation, PF, etc.

- Point of Connection to PPL EU and phase identification. NOTE: if the generation phase sequence is different then the PPL EU phase sequence, both must be shown on this diagram.

8.2.2 Current Elementary Diagrams

- Terminal designations of all devices - Relay coils and contacts, switches, transducers, etc.
- Relay Functional Designation - Per latest version of ANSI/IEEE standard C-37.2 The same functional designation shall be used on all the drawings showing the relay.
- Complete relay type such as "SEL 321", etc., and the relay range.
- Range and settings of timing relays.
- Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
- All switch contacts are to be shown in the open position with each labeled to indicate the positions in which the contacts will be closed.
- Switch contacts shall be referenced to the switch development if development is shown on a separate drawing.
- Isolating points (States sliding links, test switches, etc.).
- Grounding of CT cables.
- All other circuit elements and components with device designation, rating and setting where applicable.
- Current Transformers - Polarity marks, rating, tap, ratio, and connection. Include the rating factors and accuracy classes (i.e. 2000/5 amp, C800/0.3 B1.8)
- Auxiliary CT ratios, connections and polarity, winding current rating, and arrows to indicate assumed current flow.
- Phase designations and rotation of both PPL EU and customer.
- Cable connection number or wire designation.

8.2.3 Potential Elementary Diagrams

- Terminal designations of all devices – relay coils and contacts, switches, transducers. etc.
- Relay functional designation – per latest version of ANSI/IEEE standard C-37.2. The same functional designation shall be used on all the drawings showing the relay.
- Complete relay type such as "SEL 321", etc., and the relay range.
- Relay contacts shall be referenced to the drawing when the coil is shown, provided the coil is shown on a separate drawing.
- Relay contacts should be shown with each referenced to the drawing where they are used. Contacts not used should be referenced as spare.
- Range and settings of timing relays.
- Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
- All switch contacts are to be shown in the open position with each labeled to indicate the positions in which the contacts will be closed.
- Switch contacts shall be referenced to the switch development if development is shown on a separate drawing.
- Isolating points (States links, test switches, etc.).
- Grounding of cables.
- All other circuit elements and components with device designation, rating, and setting where applicable.
- Coil voltage for all auxiliary relays.
- Potential transformer – nameplate ratio, polarity marks, rating, primary and secondary connections. Include accuracy class and burden (i.e. 40250/115 0.15 WXMYZ)
- Phase designations and rotation of both the utility and customer.
- Current ratings and designation of all fuses.

8.2.4 Control Elementary Diagrams

Control elementaries are to be functionally complete schematics. They should be as simple and uncluttered as possible, and shall contain the following information:

- Terminal designations of all devices – relay coils and contacts, switches, transducers, etc.
- Relay functional designation – per latest version of ANSI/IEEE standard C-37.2. The same functional designation shall be used on all the drawings showing the relay.
- Complete relay type such as "SEL 321", etc., and the relay range.
- Range and settings of timing relays.
- Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
- All switch contacts are to be shown in the open position with each labeled to indicate the positions in which the contacts will be closed.
- Switch contacts shall be referenced to the switch development if development is shown on a separate drawing.
- Isolating points (States links, test switches, etc.)
- All other circuit elements and components with device designation, rating, and setting where applicable.
- Cable connection number or wire designation.
- Device auxiliary switches (FIDs, contactors) should be referenced to the drawings where they are used.
- Any interlocks; electromechanical, key, etc.
- Coil target ratings; on dual ratings underline the appropriate tap setting.
- Complete internals for electromechanical protective relays. Solid-state relays may be shown as a “black box,” with power supply and output connections, but manufacturer’s instruction book number shall be referenced and terminal designations shown.
- DC fuses protecting the point of contact relaying and FID’s control circuit shall be monitored for blown fuse or open circuit with a yellow indicating light.
- The trip coils of lockout relays should be monitored.

- The coils and contacts of all timers and lockout relays shall be wired through States links or equivalent terminal blocks to provide isolation for testing.

8.2.5 Front View Diagrams

This drawing will show the physical arrangement of all the control and protective equipment for the IPR (and POC) relaying and shall contain the following information:

- Nameplates shall be provided for all switches, lights and hand-reset lockout relays for the purpose of identification.
- The IPR relaying shall be mounted in a separate IPR cabinet. If POC relays will be included, they must be clearly differentiated from the IPR relaying.
- The IPR relays shall be mounted in the cabinet in such an order that equipment associated with the various phases will be in A-B-C (PPL EU phase names) order from top to bottom or from left to right when facing front of panel on which they are mounted.

8.3 DRAWING REVIEW AND ACCEPTANCE PROCEDURES

- The IPP must submit preliminary POI relaying drawings for PPL EU review and acceptance. All preliminary metering drawings must be submitted for review and acceptance by the Supervisor, Meter Engineering. These drawings must be submitted before the customer's equipment is ordered to ensure that it meets PPL EU requirements.
- The IPP must submit final POI relaying drawings for PPL EU review and acceptance before the customer’s facilities will be allowed to be connected to the PPL EU system and placed in-service. All final metering drawings must be submitted for review and acceptance by the Supervisor, Meter Engineering. PPL EU will not be held responsible for possible late connection of customer’s facilities if drawings are not received in time for review.
- The type of drawings submitted must be according to the list described under "Type of Drawings Required."
- All drawings submitted to PPL EU for acceptance must contain complete information as outlined under "Contents of Drawings."
- The drawings submitted by the IPP to PPL EU for review apply only to POI switching devices and POI relaying.
- PPL EU will review the IPP's drawings and provide comments within 15 working days from the day a complete set of drawings and information are received by Substation Engineering.

- Specific Grading Plan, Foundation Plan, Foundation Details, Conduit Plan, Structural Steel Assembly, and Structural Steel Fabrication Detail drawings do not require PPL EU review.

- The responsibility of detailed and correct design lies with the IPP. Neither PPL EU nor any person acting on behalf of PPL EU:

    - Assumes any responsibility for correctness of design, drawings, installation, or operations.

    - Assumes any liability with respect to the use of, or from damages resulting from the use of, any comments disclosed in this document or in any other PPL EU correspondence with the customer.

8.4 FINAL AS-BUILT DRAWINGS

The customer must provide to PPL EU two (2) copies of the As-Built drawings listed in Section 8, Subsection 8.1. Also include copies of any and all inspection certificates with the copies.

The 'Final As-Built' drawings can be provided in:

- **Hard copy**
- **Auto CAD format**
- **PDF format**

If providing hard copy, the text must be legible. For example, a 'D' size Drawing (22x34 inches) cannot be submitted as a 'C' or 'B' size final drawing.

NOTE: Final as-built drawings are required to be completed and submitted to PPL EU within 60 days of the initial synchronization of the generation.

SECTION 9 LIST OF APPLICABLE ANSI, IEEE, NEMA, NFPA AND UL STANDARDS

This document will be applied in conjunction with other industry standards pertaining to generation and PPL EU intertie installations, the latest versions at the time of this revision:

- ANSI/IEEE C12.1-2014, Electric Meters—Code for Electricity Metering
- ANSI C12.20-2015, Electricity Meters—0.1, 0.2 and 0.5 Accuracy Classes
- ANSI/IEEE C37.2-2008, Standard Electrical Power System Device Function Numbers, Acronyms and Contact Designations
- ANSI C84.1-2016, or latest version, Electric Power Systems and Equipment – Voltage Ratings
- IEEE Std. C2-2017, National Electrical Safety Code
- IEEE Std. C37.90.2-2004, IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
- IEEE Std. C57.12.00-2015, IEEE Standard for General Requirements for Liquid Immersed Distribution, Power and Regulating Transformers
- IEEE Std. C57.13-2016, IEEE Standard Requirements for Instrument Transformers
- IEEE Std. 80-2013, IEEE Guide for Safety in AC Substation Grounding
- IEEE Std. 81-2012, IEEE Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System
- IEEE Std. 315-1975 (R1989), IEEE Standard for Graphic Symbols for Electrical and Electronics Diagrams
- IEEE Std. 487-2015, IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations – General Considerations
- IEEE Std. 519-2014, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
- IEEE Std. 81-2012, IEEE Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System
- IEEE Std. 929-2000, IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems
- IEEE Std. 1547-2003, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
- IEEE Std. 1547.1-2005, or latest version, Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
    - Generation installations certified to be compliant with IEEE 1547.1 will generally be accepted as designed. In these cases, an IPR (Intertie Protective Relay) cabinet will not be required, as the required protective functions will be included in the generation package. IEEE 1547 is limited to Distributed Resource [generation] installations of 10 MVA or less for a single installation and 10 MVA or less for multiple generator installations on a single line or substation. For the PPL EU system, most of these installations will be at 12 kV. PPL EU will accept IEEE 1547.1 certified generators for parallel operation on its system up to 2.0 MW, with no additional system modifications. However, installations above this limit will be reviewed to determine if additional protection, beyond that provided by IEEE 1547 is required. In general, IEEE 1547 will not be

accepted or applied to generators connecting at the 69 kV and higher voltage levels.

- The PJM Small Generation (0 to 2.0 Mw) interconnection requirements will be used in place of the PPL EU for facilities in this range *AND UNDER THE JURSIDICTION OF PJM.* Units in this range, but not under PJM jurisdiction will be classified as Inverter, and units failing the screens will be classified as TYPE 1, 2, 3 or 4 as appropriate.

- CERTIFIED equipment will be tested and certified by a NRTL (Nationally Recognized Testing Laboratory) to IEEE 1547.1-2005 (or the latest version). **All inverters to be used for connecting generation to the PPL EU system are required to be certified to UL1741 and IEEE 1547. The term certified is understood to indicate that NRTL has tested the device to the appropriate standard, in this case UL1741 and IEEE 1547. Any inverter not meeting the NRTL certification will either not be allowed to connect to the PPL EU system or will be required to install suitable external protection equipment to provide the same level of protection. Further, the inverter vendor must provide upon request copies of the certification of the inverter equipment from the NRTL. Self-certification or certification by a third party that is not listed on the OSHA web site will not be accepted.**

- IEEE Std. 789-2013, IEEE Standard Performance Requirements for Communication and Control Cables for Application in High Voltage Environments

- NEMA Standard ICS-6 1993 (R2016), Industrial Control and Systems: Enclosures

- NFPA 70-2017, National Electrical Code

- UL 1741-2010, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

APPENDIX 1

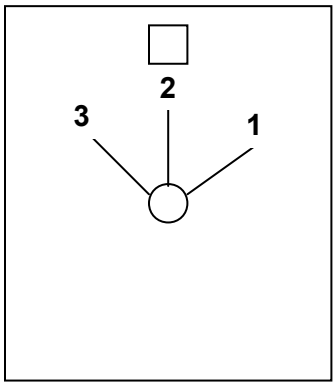
DETAILS FOR PPL EU CONTROL SWITCH (PCS)

Below is a TYPICAL control switch development showing the required functions. This information is taken from a General Electric type SB-1 switch, but alternative suppliers with the same functionality will be considered.

The switch is to have a PISTOL grip handle, with a target (or flag) indicator, and to be spring-return from the close to the normal position and from the trip to the normal position. The target (or flag) will indicate RED for the Normal After Close position, and GREEN for the Normal After Open position. The positions will be Trip, Normal, Close, from left to right when viewed from the front of the switch. The trip and close position should be approximately 45 degrees off of vertical, and the normal position will be the vertical position.

Contact	#	Trip (1)	NAT (2)	NAC (2)	Close (3)
1 1C	**1**	**X**			
2 2C	**2**				**X**
3 3C	**3**	**X**			**X**
4 4C	**4**	**X**			
5 5C	**5**		**X**	**X**	
6 6C	**6**				
7 7C	**7**	**X**	**X**		
8 8C	**8**	**X**	**X**		

FRONT VIEW:



ESCUTCHEON ENGRAVING:

1	TRIP
2	
3	CLOSE

NOTE: The Normal After Trip (NAT) and Normal After Close (NAC) position are not engraved.

APPENDIX 2

ITEMS TO BE DISCUSSED DURING THE PROJECT

This is a list of items that *generally* need to be addressed during a typical project. It is NOT all inclusive and is provided as a guide only.

1 ELECTRICAL INSPECTION
As required by local ordinances, authority having jurisdiction or other PPL EU requirements to meet the NERC FAC-001 Standard.

2 PLANT OPERATION
The IPP should meet with PPL EU to discuss effect of plant operation on which breaker is tripped, and how the IPP will maintain critical services during extended line outages.

3 ALTERNATE SUPPLY OR TWO LINE SUPPLY
Check to see if the IPP requires an alternate supply of power to aid in powering the plant, or to allow operation during outages of the normal source.

4 POC BREAKER CONTROLS
Determine how the POC (Point Of Contact) breaker is to be controlled--tripped by IPR, PCS, DTT, SCADA, etc.

5 CONTROL SCHEME AC OR DC
Check to see what type of control scheme is to be implemented. An AC scheme requires the use of an UVT (Under Voltage Trip) and series connection of all the relays and other trip contacts, while a DC scheme requires the parallel connections of all the trip contacts, and a suitable DC source.

6 AUXILIARY LOADS
Get the minimum and maximum auxiliary loads, and the amounts of load the PPL EU system will be expected to pick up immediately after a unit trip.

7 FLICKER/HARMONIC PRODUCING LOADS
Get data from the generator for all loads connected to the PPL EU system capable of producing flicker or expected to have substantial harmonic content.

8 PERIODIC RELAY SETTINGS
Discuss the arrangement for PPL EU Test Department to test the IPR relays every two years.

9 PLANT ACCESS
Set up procedure for PPL EU access to the various pieces of PPL EU equipment.

10 GENERAL OPERATING PROCEDURE GENERATOR
Review the IPP's general operating procedure to see if there are any conflicts with the PPL EU system operation.

11 VOLTAGES AT GENERATOR
Notify the IPP of the expected voltage levels at this location; review with this transformer information, especially the transformer taps.

12 FAULT DUTIES AND SHORT CIRCUIT LEVELS
Send out the latest estimate of the fault duties at the generator location.

13 CONSTRUCTION POWER
The IPP is required to contact the PPL EU field coordinator to arrange for construction power.

14 START UP POWER
Check to see when start up power is required; this is usually several months before the synchronization date.

15 IPR CABINET
Send out the list of the specific requirements for this location. Check on the location of the IPR cabinet, switchyard, control room, other? Be sure the IPP is able to read and reset the relay targets without unlocking the IPR cabinet.

16 IPR RELAYS
Send the IPP a list of the preliminary relay ranges and setting, after receipt of the one line from the IPP.

17 SOLID GROUNDING
Notify the IPP the connection for the transformer will be solidly grounded WYE on the high side, unless otherwise agreed to by PPL EU.

18 IPR INTERLOCKS
Review the operation of the PPL EU control switch (PCS) on the breaker used to isolate the generator from the system. Be sure that the voltage and frequency relays block closing of the POC breaker if the generator does not use synchronism check relaying on this breaker.

19 SYNCH CHECK RELAY
Verify that the generator has implemented the syncheck relay correctly, and that any breaker which can parallel the generator to the PPL EU system has the IPR synch check function in the closing circuit.

20 DRAWING REVIEW--ONE LINE
Review the initial generator one line; check for compatibility with the PPL EU system

21 DRAWING REVIEW--THREE LINE
Review location of CT's, PT's, metering, and other major equipment. Check the phasing of the generator system and the IPR relays vs. the PPL EU system. Also check the phase names of the IPP vs. PPL EU, on the terminal pole or dead-end structure.

22 DRAWING REVIEW--SITE PLAN
Review the site plan, for location of various major pieces of equipment; dead-end structure, the last PPL EU pole etc. Review PPL EU line crossings, and the layout of the fence, and the property lines. Whose property is the tap on?

23 DRAWING REVIEW--SUBSTATION
Review grounding details. The customer neutral/ground must connect to the PPL EU system neutral. The conductors must be capable of handling the fault current. For high

voltage installations (69 kV and above, the measured ground resistance prior to the connection of any outside facilities must 5 ohms or less). Check on the location of lighting arrestors, also voltage rating and class. Review the point of contact switch (POC), location, operation, rating, and manufacturer. Also, the switch must be capable of being locked in the open position.

24 DRAWING REVIEW--CONTROL ELEMENTARY

Review the IPR DC control elementary, and interlocks. Also the use of auxiliary or lockout relays. Verify the operation of all breakers, especially breakers that must be interlocked to avoid a misoperation of the synchronism schemes.

25 DRAWING REVIEW--POC CB

Determine the type of breaker (oil, air, magnetic, etc.) and ratings (continuous, duty, fault, and operating time). Check tripping and closing logic--pay special attention to the synchronizing and synch check circuits.

26 DRAWING REVIEW--LOW SIDE GENERATOR BREAKER

Check to see that the above breaker is suitable for the intended operation. Will this breaker withstand 2 per unit voltage in the open condition? Check tripping and closing logic--pay special attention to the synchronizing and synch check circuits. CT's must be class C400 or better, also PT's should be dual winding and rated at 200 VA minimum.

27 DRAWING REVIEW--POTENTIAL

Review the potential elementary for the correct phasing and voltage levels to PPL EU IPR equipment. Check the location of the neutral grounds in these circuits and also that there is only one ground per circuit.

28 DRAWING REVIEW--CURRENT

Review the current elementary; check CT ratio, and connections to PPL EU equipment (IPR). Check the location of the neutral grounds in these circuits and also that there is only one ground per circuit.

29 DRAWING REVIEW--IPR WIRING

Review the IPR wiring for any gross errors. PPL EU does not review the wiring drawings.

30 SYSTEM DESIGN

Review the length of the CT, PT, and DC cables, the connected burden, and the calculated voltage drop. Review the DC system, voltage level (24-48-125), minimum designed operational voltage level, fusing, primary/backup supply. Check use of the PPL EU synch check relay, and location of the relay. Review the need for breaker failure protection at the generator and review the implementation. Look into the possibility of installing a breaker 'a' switch to block voltage and frequency relays when the generator is off line to avoid nuisance trips. Review the functions of the various relays (ov/uv & of/uf are supposed to block if the synch check is not used) etc. Facilities connected at 69 kV and above will need to consider: insulation coordination, equipment ratings, operating considerations. .

31 VOLTAGE REGULATOR

Notify the IPP of the required modes of operation; check the voltage regulator for the required functions.

32 IPR CABINET

Discuss the location of various pieces of equipment (PPL EU control switch, targets, lockouts etc). The cabinet must be set up so the relays can be sealed, the PCS will be under lock and key, and that the IPP can read and reset the targets. Review the front view of the IPR cabinet, make sure relay targets can be read and reset.

33 IPR RELAYS

Review the list of the specific relays to be supplied for the IPR cabinet, check manufacturer, ranges, etc. Check to see that all relays and IEDs can be isolated by test switches (FT-1 or equal) or use drawout cases.

34 USE OF CONTACT MULTIPLYING RELAYS

If contact multiplying relays are used in any schemes associated with PPL EU controls, they must be designed for fail-safe operation.

35 METERING EQUIPMENT

Review with the generator who will supply the various pieces of equipment, and who will install this equipment. Check on the location and type of equipment indoor vs. outdoors, metering cabinet vs. switchgear. Find out when the IPP will need the PPL EU metering equipment.

36 27DC--BATTERY MONITOR OR UVT ON AC SCHEME

It may be necessary to add a time delay to the battery monitor, so that it will not operate when various pieces of DC equipment are operated.

37 RELAY TARGETS

Make arrangements for the Test Department to mark the appropriate targets with a PPL EU ID number.

38 DESCRIPTION OF OPERATION – NUG/IPP

PPL EU will write up a description of the control facilities, including IPR, DTT, SCADA, and trip and blocking points, based on specific information provided by the IPP.

39 VOLTAGE/REACTIVE SCHEDULE

Review the voltage/reactive requirements for the NUG/IPP, and see that the IPP receives and understands this information.

40 VOLTAGE REGULATOR

Obtain a description of the voltage regulator, voltage and VAR control equipment.

41 GUIDELINE FOR VOLTAGE/REACTIVE CONTROL

Be sure a guideline is created which details acceptable deviations and the action to be taken for excessive deviations.

42 5% VOLTAGE REDUCTION

Be sure to notify the IPP of the possibility of 5% voltage reductions.

43 SPARE PARTS - IPR

Inform the IPP of PPL EU's position not to carry spare parts for the IPR cabinet, also determine which components are critical to the continued operation of the IPP's facilities. List the items for which failure will require the shutdown of the IPP.

44 INITIAL SYNCHRONISM

Review the plans for the initial plant synchronism to the PPL EU system. Test Department will observe but not take an active part.

45 REVIEW OF MAIN TRANSFORMER SPECIFICATION

Check for appropriate taps, impedance, windings, grounding, etc.

46 PROJECT SCHEDULE

Get a copy of the proposed project schedule from the IPP to see if there is any impact with PPL EU work.

47 PPL EU REVENUE METERING EQUIPMENT

Send out metering equipment information or cut sheets.

48 SUBSTATION CONTROL HOUSE VENTILATION

Make sure there is adequate ventilation in the building housing the SCADA and the IPR cabinet. This is especially true if the battery is housed in the same room.

49 TECHNICAL CONTACT

Get name, address, and phone number of the contact for the project.

50 SCADA

Be sure to have a 15 amp branch circuit installed near the SCADA unit. Discuss the operation of the PPL EU SCADA with the IPP. Send out the typical form letter for ordering SCADA phone circuit. Get the phone circuit identification number. Send the IPP the protection requirements for the SCADA phone circuit.

51 POINT ASSIGNMENT SHEETS

PPL EU will create the SCADA Point Assignment Sheets for this project, and issue, based on information received from the IPP.

52 DTT REQUIREMENTS

PPL EU will provide specific information on the DTT to be installed (if this function is required), as the equipment installed at the IPP must match equipment installed at the PPL EU remote substation. Also, PPL EU will supply specific information for the telephone line associated with the DTT equipment.

53 DRAWING CROSS REFERENCE LIST

PPL EU will issue the 'as built' drawings from the generator as the drawings of record for the facility. These drawings will be listed by the PPL EU drawing numbers and the generator drawing number will be cross referenced when the final set of drawings are issued.

54 Procedure if IPR or DTT Relaying fails.

Describe the 10-hour rule for repair of the IPR or DTT relay package.

APPENDIX 3

TELEPHONE CIRCUIT ORDERING INFORMATION

The telephone entrance cable and related telephone infrastructure at your high voltage site must meet modern IEEE 487 standards. For existing facilities, this may well mean that existing telephone circuits may need to have the same high voltage protection installed or upgraded. In order to do this you will need to complete the following items, prior to the in service or the energization date of your facility. The following are general guidelines to assist you.

HIGH VOLTAGE SITE INFRASTRUCTURE

1. You will need to contact the local telephone company Outside Facilities Engineer (OFE) who can place you in contact with their High Voltage Protection Group to begin the engineering review and to initiate the process for establishing service at your high voltage facility**.** ***Be aware that the lead time to establish phone service at high voltage sites may be 3-6 months or longer*.**

2. You will be required to provide some site data to allow the telephone company to calculate the maximum Ground Potential Rise (GPR) voltage and the Zone of Influence (ZOI) at your High Voltage site and enable the telephone company to complete their design. ***These calculations will also determine if your site will be serviced by a copper entrance cable or by fiber optic cable****.* Attached is a SAMPLE of the type of information typically requested by the telephone company.

3. PPL EU Engineering can supply some sample drawings to show how these facilities are typically installed. Drawings are available for both individual telephone circuit protection and also card slot type protection for multiple telephone circuits based on a copper cable design. ***If a fiber optic cable solution is recommended, understand that each local telephone company has their own specific requirements for the physical equipment needed at your site. It is best to work with their OFE on the design.***

CIRCUIT ORDERING

1. The telephone company OFE will put you in contact with the proper group to place the order. You will need to provide the following information (see items #4 and #5 for specific wording for each type of circuit):

   - Complete 911 address (for example, 123 Main St, etc.) for your site AND the terminating ends of the telephone circuits on the PPL EU system.

   - Contact person information for your site AND the corresponding PPL EU site where the circuit(s) are being terminated.

- A required in service date. Typical lead times for a SCADA (DS-1) circuit are 6-8 weeks. A PRDA (DTT) circuit may require even longer lead times as these are NOT a tariff service and you may encounter difficulties in obtaining this service. Also, be aware that you may encounter difficulties as well if either of these circuits needs to transverse a telephone company Local Access and Transport Area (LATA) boundary.

2. You will need to coordinate the in-service date with various PPL EU groups to make certain the PPL EU facilities are ready to accept the circuits. The PPL EU Substation lead engineer following your project can assist you.

3. **We specifically request that you provide PPL EU Substation Engineering with the circuit identification and in-service date.**

4. ***DTT (Direct Transfer Trip) telephone circuits*** are a Four-Wire, 'PR' Channel, conforming to Protective Relaying Channel Specifications per Bell System Practice Section 851-201-101, tone relaying service, typically referred to as PRDA type telephone circuits, with C6 conditioning on the circuit. Note: active devices (loop-back modules, amplifiers) are not permitted on this relaying circuit at either the IPP Facility, or the PPL EU Substation. ***This tone relaying circuit is between the IPP Facility and the remote PPL EU Substation.***

5. ***SCADA (Supervisory Control And Data Acquisition)*** Four-Wire, Full Duplex 3002-C1 Data Channel for SCADA service, now typically referred to as DS-1 type telephone circuits (formerly type FDDA). The automatic loop-back assemblies required are to be passive units (no active amplifiers) and fail-safe (will not loop-back on loss of power). Any loop-back device that will cause loss of the circuit on loss of supply is not acceptable. Also, any loop-back device powered by sealing current is not acceptable. ***This data circuit is between the IPP facility and the local PPL EU Service Center.***

Power Station Request for Telecommunications Service

Telephone Company Contact

Name:
Address:
Phone:
Fax:
Email:

Customer Contact

Name:
Address:
Phone:
Fax:
Email:

Electric Substation Data:

Substation Name/Address:	
Is Substation new or existing? If existing, provide at least 1 existing telephone number	
Square Foot Area: (Total Size of Ground Grid / Ground Mat)	sq. ft.
Total Expected (line-to-ground) Fault Current: (Specify Amps RMS or Peak)	
Grid Impedance (in ohms) to Remote Earth: (Specify Measured or Calculated)	ohms (if measured use fall of potential method)
X/R Ratio:	
% Earth Return Current in Amps:	
Soil Resistivity:	
Telecommunications Peak Factor: (Determined by Telco)	
Peak Ground Potential Rise: (Determined by Telco)	
Remote Earth Point (300 V) distance from Substation Grid: (Determined by Telco)	